# ERRATA

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**Development of a Procedure to Rate the Application of Pavement Maintenance Treatments**

The following pages were printed in error.

Page 21, Figure 1 is incorrect.

Page 101, Figure 3 is incorrect.

Page 171, Figure 38 is incorrect.

The attached are replacement pages.

SHRP-M/FR-92-102

# Development of a Procedure to Rate the Application of Pavement Maintenance Treatments

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# Abstract

Although millions of dollars are spent each year on pavement maintenance, adequate information defining the benefit of preventive maintenance treatments is not available. SHRP Project H-101 has coordinated the construction of preventive maintenance treatments to determine their effectiveness.

Some of the factors that affect the life of preventive maintenance treatments are the quality of the materials used, the environmental conditions during which the treatments are placed, the type of equipment used, and the quality of the treatment application. Quantifying these factors has been difficult. This report describes an approach which has the potential of quantifying this set of diverse factors into a single rating, in the possibility that this can be related to the performance of the treatments.

# Executive Summary

Several preventive maintenance treatments are being used to preserve pavements across the nation. Limited funding for highway maintenance has created a need to substantiate the benefit from these expenditures (1). The Strategic Highway Research Program (SHRP) project H-101, Pavement Maintenance Effectiveness, is being conducted to determine the cost-effectiveness of selected preventive maintenance treatments. Six specific maintenance treatments were selected by a panel of pavement engineers to be studied. For flexible pavements, these include:

crack sealing,
chip seals,
slurry seals, and
thin overlays.

For rigid pavements, treatments include:

crack and joint sealing, and
undersealing.

The purpose of the study is to determine the effect of these maintenance treatments on pavement performance. This information can then be used with appropriate cost information to determine the cost-effectiveness of preventive maintenance treatments.

The treatments were applied to the flexible pavements during the 1990 construction season, and are scheduled to be applied to the rigid pavements during 1992. A series of tests and observations are being conducted on the treated sections and the untreated control sections before, during, and after treatment application. The initial and long-term tests and observations will be used to determine the treatment effectiveness. Long-term observations are to continue until the sections fail. The test sections are designated as Specific Pavement Sections (SPS) of the Long Term Pavement Performance (LTPP) studies of SHRP. The flexible pavement sections are designated as SPS-3, and the rigid pavement sections are designated as SPS-4. The LTPP studies are scheduled to continue for fifteen years after the initial SHRP studies are complete. It is estimated it will take this long to determine the effects of some of the treatments, especially those applied to rigid pavements.

# 1

# Introduction

## Study Design

An experimental, or sampling, design was developed to identify the impact of important, controllable (key) factors on the effectiveness of the selected maintenance treatments. Some factors common to similar LTPP General Pavement Studies (GPS), include: environmental conditions, traffic volume, and subgrade type. Others are specific to the types of treatments, pavements and materials being studied. There are also factors which cannot be controlled in the experimental design, but which we know will affect the treatment and are considered covariables.

The experimental or sampling design arranges these factors so that their influences on the effectiveness of the treatments, considered the main effects of the experiment design and the dependent variables in the analysis, can be determined. The performance of pavements with the preventive maintenance treatments will be compared to the performance of similar pavements without the application of the treatments, which are the control sections. Measures of performance will include: distress types, profile (or roughness), surface friction, structural capacity through deflection testing, and material properties.

Since the goal of this study is to determine the effect of the individual treatments in extending the pavement life, the impact of the individual materials or construction processes is not being studied. In addition, the overall goal is not really to compare the performance of one treatment to another, but rather to compare the change in performance of treated to untreated sections. The impact of the preventive maintenance treatment desired is that of the process, for example, a slurry seal. Therefore, common treatment materials, mix designs, and treatment construction specifications which are known to work reasonably well in each individual climatic zone have been selected. Although localized materials and techniques are important to the local agency, they cannot be allowed to control the national experiment. Any comparison of performance of treatments due to different material

characteristics and construction techniques should be reserved for agency specific studies, which are encouraged by SHRP and will be integrated into the data collection and analysis. The common, or site, factors in the experimental design for preventive maintenance for asphalt concrete and portland cement concrete pavements include:

| | | |
|---|---|---|
| a. | moisture: | wet<br>dry |
| b. | temperature: | freeze<br>no-freeze |
| c. | subgrade type: | fine grained<br>coarse grained |
| d. | traffic loading: | low<br>high |

Concern has been expressed that, for instance, low- and high-traffic levels will not be adequate to define the spectrum of traffic observed. The arrangement into the cells is only a mechanism to insure there are different levels in the study, not to define discrete points. In fact, it is hoped that the variables will vary considerably within each range, providing sufficient data to develop continuous relationships for all of the variables of interest.

The second set of factors are generally different for the SPS experiments from those of the GPS experiments and different for the asphalt and concrete experiments. Obviously, the individual treatments, listed previously, are included. There is no plan to explicitly evaluate the effectiveness of combinations of the treatments; each will be regarded as a separate treatment and considered alone. However, surface preparation representing good engineering practice will be included.

### *Asphalt Pavements*

The two pavement factors which have the most influence on the performance of preventive maintenance treatments applied to flexible pavements are the condition of the pavement at the time the treatment is placed, and the structural capacity of the pavement compared to the traffic loads being applied to the pavement. There was considerable discussion concerning the number of pavement condition levels to define. The preventive maintenance treatments are to be applied to the pavement sections in the hope of preventing, or reducing, the rate of deterioration. It is believed this is most effective if the pavement is in good condition, and the treatment is applied to retain the pavement in that condition level. There is a condition level at, or below, certain levels where the preventive

maintenance treatments will have little effect. It is maintained that, depending on the traffic level, some intermediate degree at which the treatments will reduce the rate of deterioration but may not be as effective if applied earlier.

Three levels are required to define the impact of condition; however, the primary goal is to define the effect of the treatments on pavements which are believed to be in a condition which will respond to the treatment. Spending money to show that pavements in poor condition will not respond well to light maintenance treatments is a cause of concern. However, if the treatments are not applied to the pavements in all three condition levels, it is possible that we will not be able to answer all of our questions. Thus, it is important to apply the treatments at a poor condition level to anchor our analysis; however, it is possible to use less than a full factorial of pavements in this condition. The structural capacity is considered a two level factor, and was initially based on structural number. The selected factors include:

| | | |
|---|---|---|
| e. | condition: | good<br>fair<br>poor |
| f. | structural adequacy: | high<br>low |

Sites are located in United States and Canadian provinces.

## *Rigid Pavements*

The two factors known to affect the performance of preventive maintenance treatments applied to the rigid pavement are pavement condition at the time of treatment and the type of subbase. Pavement condition was to be divided into three levels in an approach similar to the flexible pavement studies. The subbases to be considered were granular and stabilized bases. The selected factors included:

| | | |
|---|---|---|
| e. | condition: | good<br>fair<br>poor |
| f. | subbase: | granular<br>stabilized |

Participation in the study of preventive maintenance treatments applied to rigid pavements was not as great as hoped. As a result, the sampling plan was modified to reflect realistic expectations.

The final sampling plan for the rigid pavement included the following factors for plain jointed pavements:

| | | |
|---|---|---|
| a. | moisture: | wet<br>dry |
| b. | temperature: | freeze<br>no-freeze |
| c. | subgrade type: | fine grained<br>coarse grained |
| d. | subbase: | granular<br>stabilized |

For jointed reinforced pavements, only the wet moisture level was considered. It appears that for rigid pavements, only joint and crack sealing will be adequately represented to determine their impact on performance.

### *Covariables*

Covariables are measured independent variables which are not used in the basic design to select the treatment locations. Although they are suspected of having an impact on the performance of the preventive maintenance treatment, they cannot be controlled in the experiment. Primary reasons for not controlling them include: monetary constraints (keeping the number of sections within the study to a reasonable level), lack of available candidate sections, and lack or prior knowledge during the site selection process. Covariables which were identified for the preventive maintenance applied to flexible pavement include: age, layer thicknesses, layer material properties, shoulders, subdrainage, prior maintenance, quality of the treatment construction or application, treatment material properties, and environmental conditions at the time of treatment application. In addition to those covariables mentioned for the flexible pavement studies, the covariables for preventive maintenance applied to rigid pavements include slab length and load transfer. Several other uncontrolled and unknown variables are sure to exist.

## Construction Plan

Some of the covariables which are known to affect the performance of the treatments include: material properties, mix design procedures, construction equipment, construction crew experience and training, and application procedures. Many of these factors change dramatically from location to location. However, since the use of a specific material or construction technique is often limited to a small geographic or political area, there is no need to determine impact of localized factors over a large area. Each additional factor varied in the analysis would at least double the number of sections which would have to be

constructed for each treatment. Therefore, a common set of treatment materials, mix designs, and treatment construction specifications which are known to work reasonably well in the four SHRP regions were selected.

If the construction variables can be controlled, the impact of the key variables and their interactions on the effect of preventive maintenance treatments can be determined. This will provide the desired North American "base line" analysis of the impact of the treatments on the pavement performance. Inferences which can be made from the analysis will be limited to the range of the controlled factors. However, since the number of variables is limited in a localized area, a smaller number of test sections will need to be evaluated on a local or regional basis to develop a "shift factor" for use with the overall base line analysis. The results of the overall study could then be applied to local analysis as well.
There has been considerable concern from the beginning of the project over how to control key variables of the study. Since SHRP does not have the funds to pay for construction of the treatments, participating agencies will fund the building of the treatment test sections. The concept advocated in the original proposal was to develop a strict set of specifications and allow the participating agencies to control application. However, the SHRP Highway Operations Advisory Committee decided to develop an approach which would limit the construction to one crew, one equipment set, and one set of material sources for each treatment. This concept was agreed to at the first meeting of the H-101 Expert Task Group (ETG). This concept was modified to allow the use of single crews, equipment sets, and material sources in each of the four climatic regions for each of the flexible pavement treatments, except for the thin overlay. It was apparent the thin overlay could not be controlled in the same manner because of the equipment required to prepare the asphalt concrete. Because initial participation in the preventive treatments applied to the rigid pavements was lacking, regional contracts for the SPS-4 tests were unable to be developed.

Three general options to control construction were considered by potential participating agencies. In addition to the regional contractor option, a second alternative included providing the participating agencies with the means to control the application, but requiring centralized material purchase; a strict set of specifications; specialized quality control assistance; and centralized mix design. All of these choices would be accompanied by special training. The third possibility would allow construction of the treatments using a set of common specifications agreed upon by the participating agencies within the region. The final result allowed regional contractors to apply the chip seals, slurry seals, and crack sealing. In addition, a single source of materials for the crack sealant, slurry seal, and chip seal materials was used in each region. The thin overlays of the flexible pavements and joint/crack sealing and undersealing of the rigid pavements are being constructed by each participating agency using a set of guide specifications developed by the SHRP staff.

The Federal Lands Highway Divisions (FLHD) of the Federal Highway Administration (FHWA) served as contracting authorities for the construction activities in each of the SHRP regions. The participating agencies formed a regional task group (RTG) in each of the four regions. Members of the RTG include state and provincial highway engineers who, along with FHWA and SHRP representatives, selected a regional contractor to apply the chip seal, slurry seal, and crack sealing treatments.

The selection of the contractor(s) for the three common-crew, common-material treatments was accomplished in two steps. First, a solicitation of interest from contractors was advertised. From this, a list of interested contractors was generated. FLHD officials and the RTG reviewed this list to determine a short list of qualified contractors, based on an outline of predetermined qualifications. Each prequalified contractor on the short list was then asked to submit a cost proposal. The winning bid was selected from among these final proposals.

Each contractor purchased all of the materials required for the sites within the region at one time from one set of sources and stockpiled the material as necessary. Using a single crew and a single set of equipment, the contractor applied the treatments at each site within the region, and was responsible for quality control during construction. The SHRP Regional Coordinating Office Contractor (RCOC) conducted extensive checks on the construction of the treatments. All material sampling, material testing, and mix designs was conducted under RCOC supervision, except for the thin overlay materials and treatments applied to rigid pavements. The thin overlays are to be a standard dense graded asphalt concrete normally used by the respective highway agency. The participating agencies are responsible for all material sampling, material testing, and mix designs for the treatments applied to rigid pavements; however, the RCOCs are providing assistance and training.

Final acceptance of the regionally-contracted work was the responsibility of FLHD, which was the contracting authority. Although the test sections are located on state or province highways, and the participating agencies assisted in final acceptance, the final acceptance for contract administration came from FLHD.

## Measuring Quality of Construction

The primary purpose of this report is to present a rating procedure which was developed to evaluate the quality of application of the preventive maintenance treatments to flexible pavements. The three maintenance treatments selected for this--chip seals, slurry seals, and crack sealing--are the three which were placed under contract. The rating procedure is designed to assign a numerical value to the treatments which indicates how well the treatment was applied. Dr. Lytton developed the concept for this in an early evaluation of SHRP needs (2).

Quantifying the application of a treatment is difficult because of a large number of activities and factors which have an impact on the performance of the treatment. To rate the treatment quality, information pertaining to application of the treatment must be obtained. The approach used in this study was to identify all of the factors and activities expected to have an impact on the effectiveness of the treatment. After these items were identified, data collection sheets were developed to collect the necessary information. Chapter 2 explains how the data collection sheets were developed and describes the importance of their features and uses in the rating procedure.

Rating trees were developed to evaluate the information recorded on the data collection sheets. The trees were generated through a combination of decision tree theory and utility theory. A separate rating tree was developed for each of the three treatments considered. The trees rate the items individually, and then combine individual measures to provide an overall rating for the treatment. The rating trees are structured in a manner which allows the individual criteria to be weighed according to their relative importance, enabling items of greater significance to account for more of the overall rating. Details on the development and evaluating procedures of the rating tree are explained in Chapter 3.

Details on the individual rating criteria for chip seals, slurry seals, and crack seals are given in Chapters 4, 5, and 6 respectively. These chapters explain the weights assigned to the main attributes, attributes, and sub-attributes. They also discuss the rating values assigned to the individual rating criteria. Conclusions and recommendations are given in Chapter 8.

The overall rating provided by the rating trees is indicative of how well the treatment was applied, and it is expected to be helpful as an indicator of future performance of the treatment. This rating procedure should help determine how important the various factors are, and which areas of construction need to be improved or more closely controlled to obtain a final product which will be more effective in serving the road users. The rating is intended to serve as an example for highway agencies.

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# Development of Data Collection Sheets

Data collection sheets, as shown in Appendix A, are forms designed to record specific information. They are used in this study to collect data related to the application of chip seals, slurry seals, and crack sealing. The data is necessary to evaluate the application of the treatments for the purpose of predicting the performance of the treatments.

The data collection sheets serve three main purposes in the data collection and evaluation processes. First, they provide an on-site inspector with a list of the important items to be recorded. Second, they provide a systematic manner of collecting the information to assure that the same type of data elements are collected for all similar treatments to facilitate evaluation on the same basis. And third, they provide the necessary data for the rating procedure.

## Sources of Information

The development of the data collection sheets required an extensive review of application procedures for the three pavement maintenance treatments to determine what data would need to be recorded to evaluate the application of the treatments. A variety of sources were consulted to gain as much information as possible. The sources include construction manuals for chip seals (3, 4, 5, and 6), slurry seals (7, 8, and 9), and crack sealing (10 and 11); practical knowledge from associates and experts with field experience; and data collection sheets from the SHRP Long Term Pavement Performance Program (LTPP).

## Selection of Data Items

It is hard to over-emphasize the importance of developing a good data base in order to properly evaluate the application of a pavement maintenance treatment. Any information

which is expected to have an influence on the effectiveness of the treatment was considered. However, the collection of unnecessary data is burdensome and expensive, while recordingtoo little will not allow proper evaluation of the treatment. Therefore, careful consideration was given to determine the information necessary to perform an adequate analysis for the study at hand.

The possible information identified from all of the sources was compiled for each of the treatments separately, and carefully examined to determine which items were necessary to support the evaluation process. It was determined that data relative to environmental conditions, surface preparation, equipment condition, application procedures, traffic control, and curing conditions are essential for the evaluation process. The importance for each selected data element is discussed in the descriptions of the three rating trees in Chapters 4, 5, and 6.

Some of the items requested on the data collection sheets are not used for the rating procedure. Some examples are the length and width of the test section, and the types and grades of materials used. These are items necessary for various identification purposes, and are easily stored in the data base for future reference.

## Classification of Data

Items recorded on the data collection sheets fall into one of the following three classifications: quantitative, qualitative, or descriptive (12). Quantitative items are measured values such as the rate of asphalt application or the time allowed for curing. This type of item is entered onto the data collection sheets in a numerical form as the actual measured value. A qualitative item describes the condition of something which has to be determined by judgement such as the moisture level of the surface or how well a procedure was performed. These are the most difficult items to accurately assess due to the subjective judgement involved during the data collection process. Specified terms are listed on the data collection sheets and used by the inspector to describe the condition. Inspectors using the data collection sheets should be familiar with the definitions of the terms used to describe qualitative items to ensure uniformity of judgement. Descriptive items describe which method or material was used, and may also appear as a "yes or no" question. Qualitative and descriptive items are recorded on the data collection sheets as index numbers. The index numbers are used to represent the specific terms which have been selected to describe the possible conditions. The terms are listed on the data collection sheets beside their corresponding index numbers and near the items which they are used to describe.

The use of index numbers facilitates storage of the data in the data base. In addition, it simplifies data analysis. Numerical indices allow easier sorts, quicker comparisons, and simpler ordered tabulations. The data base manager and reporting systems can be programmed to use the name or description of the qualitative or descriptive item response in reports.

## Organization and Format

The organization of the data collection sheets reflect the relationship between this study and the nationwide SHRP study. The data collection sheet format had previously been established, and this study tried to use that format as much as possible (13). The data requested at the top of the sheets, which identify the state and the particular test section for which the application data was recorded, are used in the data base to identify data collection sites. The term SPS stands for Specific Pavement Studies, and the numeral 3 denotes the study of preventive maintenance for flexible pavements in the SHRP study. LTPP is an acronym for Long Term Pavement Performance, and is an element of the SHRP study. The grouping of similar data items (i.e., environmental conditions, surface conditions, equipment details) was made to simplify the collection process for the inspector.

The format of the data collection sheets was chosen to simplify the process of entering the data into a computer data base system. All of the data is neatly recorded along the right side of the paper, with only one item per line. This format enables the person entering the data into a microcomputer-based screen entry system to proceed easily down the right side of the page without having to scan the whole page searching for the data.

## Relationship to Data Base

A data base is a collection of information which has been logically organized (14). Data bases are usually stored in some manner which allows the information to be retrieved when needed. The storage mechanism can range from a simple manual filing system to a main frame computer system (15). The rating procedure developed in this study requires the use of a data base to evaluate the application of pavement maintenance treatments. The data base format was developed by a SHRP contractor. It is a relational data base with a very large number of relationships and data elements. The data collection sheets were developed to provide the data needed for entry into the data base, which is necessary for the rating procedure.

# 3

# Development of Rating Trees

The rating trees developed in this study are hierarchical assessment structures. They were designed to evaluate the application quality for chip seals, slurry seals, and crack seals, and assign numerical ratings for the application of the treatments based upon application data.

The rating trees serve two main purposes in the development of the evaluation process for the application of the three preventive maintenance treatments. First, they simplify the process of assigning weights and rating values to the rating criteria as they provide a diagram similar to decision trees. The diagram enables one to see how the various items recorded on the data collection sheets interact. Second, the trees provide a systematic manner of evaluating the application of the treatments based on information recorded on the data collection sheets described in Chapter 2.

## Foundation of Rating Tree Concept

The rating tree concept evolved from a popular tool used in decision theory known as the decision tree. A decision tree is a diagram of the choices available to a decision maker when trying to solve a problem (16). The diagram allows the decision maker to view all available options and the possible outcomes available with each option (17).

Decision trees will usually reveal one choice which is superior to the others, helping the decision maker decide which alternative should be chosen.

A diagram similar to the decision tree offered a simple and very useful way to decompose the application information recorded on the data collection sheets. However, the mathematical operation of the decision tree could not be set up to evaluate the multiple rating criteria needed in the rating procedure. Although decision trees and rating trees are both drawn in a manner such that the trunk of the tree is on the left, and the branches develop to the right of the trunk, there is a major difference in the functions of the trees.

Decision trees are based on probabilities associated with the possible outcomes of the available choices. The mathematical operations of decision trees yield the various expected outcomes to the right of the diagram, beside the terminal branches. This allows a comparison of the expected outcomes to determine which choice offers the most promise.

As shown in Appendix B, the rating trees are based on weights and rating values assigned to the multiple rating criteria. The rating criteria are listed on the terminal branches of the tree with their respective rating values. Weights, which reflect the relative importance of the individual rating criteria, were assigned to the branches leading up to the rating criteria. A single numerical value for the application of a treatment is derived from the multiple rating criteria through a series of mathematical operations which move through the rating tree from right to left.

## Additive Weighting Methods

Simple additive weighting is a procedure used for multiple objective decision making. This method requires the decision maker to identify the attributes of the available alternatives for the purpose of assessing the alternatives (18). The assessment is based upon a weight assigned to each attribute and a scale of numerical values within each attribute. The weight reflects the relative importance of the attribute, and the numerical scale reflects the decision maker's preference for the attribute. An assessment value, or rating, can be determined for each alternative by multiplying the weight of each attribute by the numerical scale value for the alternative and summing the products of the attributes.

Hierarchical additive weighting is similar to simple additive weighting, but it is able to consider multiple levels of attributes. Once the higher level attributes have been defined, they are divided into several lower-level attributes. The rating of a higher level attribute is determined by combining the ratings of its lower level attributes. The ability of an alternative to satisfy higher level attributes depends on the alternative's ability to satisfy the lower level attributes. The overall assessment value for an alternative is the combined ratings of the higher level attributes.

The rating trees developed in this project are basically hierarchical additive weighting models. However, they were developed in a reverse order. Normally, the higher level attributes are identified first, but this is not the case for the rating trees. Identification of the necessary rating criteria was the first step. This was followed by the categorization of the data into the main attributes. All other aspects of the rating trees follow basic hierarchical additive weighting philosophy.

Some previous uses of hierarchical additive weighting include a feasibility study of pavement rehabilitation techniques (19), and the evaluation of equipment and analyzing procedures used for nondestructive testing of pavements (20). It has also been employed to evaluate the safeguards adequacy of nuclear facilities (21). Utility theory was used in these three studies to determine the values assigned to the trees.

## Assignment of Weights and Rating Values

The weights and rating values assigned to the rating trees follow the general concepts of additive utility models, however there is some variation. The weights reflect the relative importance of the main attributes, attributes, and sub-attributes. The rating values are the utility values for the rating criteria. Additive utility theory requires the attributes to be additively independent (17). This means the sum of the weights of a group of attributes describing a particular item should equal one. This condition was met throughout the three rating trees.

Additive utility theory also places requirements on the utility values for the best possible and worst possible outcome of each attribute (17). The best outcome should have a rating (or utility) of one, and this condition is met by the rating trees. The worst outcome should have a rating of zero, but some of the rating tree attributes do not exactly follow this. The worst condition rating value for some of the attributes is greater than zero. A closer study may even reveal the need for some worst condition rating values to be less than zero. This might be necessary for items which could, by themselves, ruin the effectiveness of a treatment.

## Mathematical Operations of the Rating Trees

A quick look at the trees reveals a combination of addition and multiplication operations. An addition sign (+) occurs at places where two or more branches diverge from a common point, with the exception of the rating criteria. A multiplication sign (x) is found beneath all branches, except the rating criteria.

The first step that must be taken is the selection of the rating criteria which correspond to the collected data. Once the proper rating criteria have been determined, the calculation procedure begins. This process begins at the far right with the rating criteria, and moves branch by branch to the left.

The rating value for each selected rating criteria is multiplied by the weight of the branch from which it extends. The resulting product of these two factors is then added to other products where the branches merge. The value obtained from the sum of the merging branches is multiplied by the value of the branch to the immediate left of the merge point. This process of multiplying and adding continues until all of the branches have been worked through, and a numerical rating value has been obtained for the tree. The following example is provided to clarify the mathematical operations.

## Example Calculations

The data used in this example was collected at a SHRP SPS-3 test site. The data is from a chip seal surface treatment, and is shown on the completed data collection sheets in

Appendix C. The calculations for the environmental main attribute branch are shown in Figure 1, and are explained, step by step, below.

The calculations begin by multiplying the rating of each selected rating criteria by the weight of the branch from which it extends. The weight for the branch labeled DATE OF WORK is 0.3. The selected rating criteria for this attribute is AFTER AUG 31, and has a rating of 0.6. The calculation for the DATE OF WORK attribute is:

$$0.3 \times 0.6 = 0.18.$$

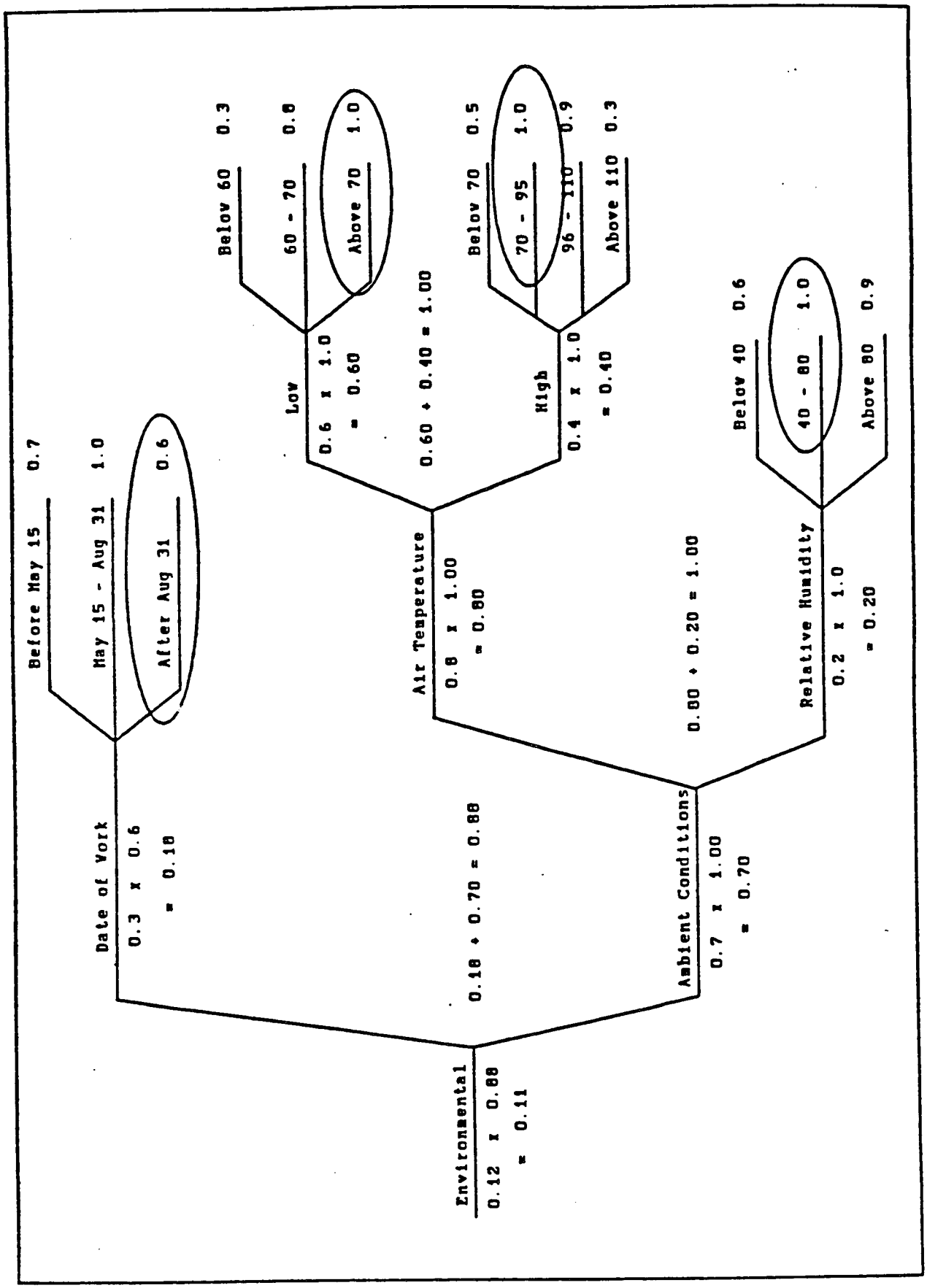


Figure 1. Example - Chip Seal Environmental Main Attribute Branch

Thus, the value for the DATE OF WORK attribute branch is 0.18, and it is carried to the next mathematical operation and added to the value for the AMBIENT CONDITIONS attribute branch.

The value for the AMBIENT CONDITIONS attribute branch includes several more mathematical operations than were needed for the DATE OF WORK attribute branch. AMBIENT CONDITIONS has two sub-attributes, AIR TEMPERATURE and RELATIVE HUMIDITY. The AIR TEMPERATURE sub-attribute branch also has two branches, LOW and HIGH. The weights for the LOW and HIGH branches of the AIR TEMPERATURE sub-attribute are 0.6 and 0.4 respectively. Their corresponding selected rating criteria are ABOVE 70 for LOW with a rating of 1.0, and 70 - 95 for HIGH with a rating of 1.0. Calculations for obtaining the LOW and HIGH sub-attribute branch values are:

$$\text{LOW} \quad 0.6 \times 1.0 = 0.60,$$

and

$$\text{HIGH} \quad 0.4 \times 1.0 = 0.40.$$

The next step is to sum the values for the two branches, and multiply the sum by the weight of the AIR TEMPERATURE sub-attribute branch, which is 0.8. This gives a value for the AIR TEMPERATURE branch of 0.80, as follows:

$$\text{LOW} + \text{HIGH} = 0.60 + 0.40 = 1.00,$$

and

$$\text{the product,} \quad 0.8 \times 1.00 = 0.80.$$

The value for the RELATIVE HUMIDITY sub-attribute branch is found by multiplying its weight of 0.2 by the rating of its selected rating criterion, 40 - 80, which is 1.0. The product is 0.20, as shown:

$$0.2 \times 1.0 = 0.20.$$

The value for the AMBIENT CONDITIONS attribute branch is the product of its weight, 0.7, and the sum of its two sub-attribute branches, AIR TEMPERATURE and RELATIVE HUMIDITY. This value is found to be 0.70.

AIR TEMPERATURE + RELATIVE HUMIDITY
0.80 + 0.20 = 1.00

and,

the product 0.7 x 1.00 = 0.70.

Now that the values for the DATE OF WORK and AMBIENT CONDITIONS attribute branches have been found, their values are summed and then multiplied by the weight of the ENVIRONMENTAL main attribute branch, 0.12.

DATE OF WORK + AMBIENT CONDITIONS
0.18 + 0.70 = 0.88

and,

the product 0.12 x 0.88 = 0.11.

From this example, it can be seen that the rating for the ENVIRONMENTAL main attribute branch of the CHIP SEAL tree is 0.11. The ratings for the other main attributes are found in the same manner that the rating for the ENVIRONMENTAL branch was found:

1. First, select the appropriate rating criteria to represent the data collected in the field;

2. Second, follow through the designated mathematical operations shown along the branches of the tree, moving from right to left.

The following are the ratings calculated for the other main attribute branches from the data in Appendix C.

| | |
|---|---|
| SURFACE CONDITIONS | 0.10 |
| EQUIPMENT | 0.24 |
| CONSTRUCTION | 0.33 |
| CURING / TRAFFIC CONTROL | 0.10 |

The overall rating for the application of the CHIP SEAL surface treatment is the sum of the ratings for the five main attribute branches.

0.11 + 0.10 + 0.24 + 0.33 + 0.10 = 0.88

Thus, the overall rating for the CHIP SEAL application data shown on the data collection sheets in Appendix C is 0.88.

4

# Chip Seal Attributes and Rating Criteria

Descriptions of the various branches of the chip seal rating tree are given in this chapter. Rating criteria for the chip seal surface treatment are divided among five main attributes: environmental, surface condition, equipment, construction, and curing/traffic control. Each of these five main traits have attributes and sub-attributes which are used to ultimately produce an overall rating of the chip seal surface treatment application process.

The main attributes, attributes, and sub-attributes are described separately. Each one has an explanation of what it represents and justification for the weight assigned to it. Justification for the ratings assigned to the rating criteria and the effect they have on the surface treatment are also listed.

The descriptions begin with environmental, which is the first main attribute. All attributes, sub-attributes, and rating criteria related to environmental are then described. The same procedure is followed for the other four main attributes and their corresponding attributes, sub-attributes, and rating criteria.

The following weights were assigned to the main attributes: environmental, 0.12; surface condition, 0.12; equipment, 0.25; construction, 0.36; and curing/traffic control, 0.15. The weights are based on the expected relative importance of the main attributes, and the number of rating criteria within them. The large number of rating criteria associated with the construction and equipment attributes warrant the higher weights assigned to them.

## Environmental

The environmental rating criteria is divided into two attributes: date of work and ambient conditions. These are important items to be considered for a chip seal, because warm weather and long curing periods help stronger bonds to develop between the aggregate and

the binder. Date of work was assigned a weight of 0.3, and ambient conditions was assigned a weight of 0.7. The higher weight assigned to ambient conditions is attributed to the three rating criteria associated with it, compared to only one for date of work.

### *Date of work*

This refers to the time of year in which the work is performed. It is important for considering the impact of curing conditions expected based on average climatic conditions. Long curing periods during warm weather are preferred because this allows maximum time for the aggregate to bond to the binder and for some beneficial embedment of the aggregate into the existing pavement surface. For most climates, the best time is the period of May 15 - August 31. The climatic conditions during that period should provide the warm temperature and adequate curing periods prior to cold weather. Work performed before May 15 is expected to have longer curing periods than work done after August 31, and is given a slightly higher rating value for this reason. However, in both of these time periods, the evening temperatures and temperatures during the days immediately following the application could be much cooler than desired. In some areas, such as those with very hot climates, this season will need to be changed to avoid the hottest periods if an emulsion is used as the binder material.

### *Ambient Conditions*

Air temperature and relative humidity are sub-attributes of ambient conditions. Air temperature received a weight of 0.8 and ambient conditions received a weight of 0.2. The higher weight for air temperature is because it has two rating criteria compared to one for relative humidity, and because temperature has a greater impact on the curing process than relative humidity.

### Air temperature

Both the low and the high air temperature are recorded under the air temperature sub-attribute. Temperature plays an important role in regard to the bond developed between the binder and the aggregate. Low temperatures slow the curing process, slow the separation of water from the binder, and cause the binder to become stiff quickly. When the binder is stiff, rolling may break the bond between the aggregate and the binder. This happens as the roller pushes the individual stones into the binder and the stiffness of the cooled binder prevents it from flowing with the movement of the stones. High temperatures may cause the emulsion to break prematurely and skim prior to developing adhesion with the cover aggregate. The weight assigned to low air temperature (0.6) is higher than the weight for high air temperature (0.4) because low temperatures have more effect on the development of strong bonds.

Low air temperature is the lowest temperature encountered during the construction process. This will usually be the temperature at the beginning of the work, although cooler temperatures may occur after work has begun. Ranges of below 60°F, 60 to 70°F, and above 70°F are used to rate this sub-attribute. Below 60°F received the lowest rating because low temperatures slow the curing process, which retards the development of the bond between the asphalt and the aggregate. Adequate bonding is expected when the low temperature is between 60 and 70°F, but it received a rating slightly less than the best condition, which is above 70°F.

High air temperature is the highest temperature encountered during the construction process. The ranges given for high air temperature are below 70°F, 70 to 95°F, 96 to 110°F, and above 110°F. Slow curing would be expected if the high air temperature is below 70°F, and it has been assigned a relatively low rating. The highest rating was assigned from 70 to 95°F because it is the best condition for curing and bonding. The 96 to 110°F range was also assigned a high rating, but is not considered to be the best condition because the high temperatures could cause the emulsion to skim or break. The lowest rating belongs to the above 110°F range, as temperatures this high may cause the emulsion to skim, preventing the development of an adequate bond between the asphalt and the aggregate.

### Relative humidity

The relative humidity effects the evaporation rate of the water in the emulsion. Low humidity will increase the evaporation rate, and may cause the emulsion to break early. High relative humidity can also be a hindrance, as the water may be slow to evaporate after the emulsion breaks. The following three ranges for relative humidity have been defined: below 40 percent, 40 to 80 percent, and above 80 percent. Below 40 percent received the lowest rating as it could cause the emulsion to break early. The 40 to 80 percent range received the highest rating because it will not cause early breaking of the emulsion, or significantly delay the evaporation of the water after the emulsion breaks. Above 80 percent has a rating between the other two. Above 80 percent humidity will not cause the emulsion to break early, but it may delay the curing by retarding water evaporation after the emulsion breaks.

## Surface Condition

The pavement surface must be properly prepared and in good condition to obtain strong bonds between the asphalt and the old surface. Failure to do this will result in loss of the chip seal as the aggregate and the binder will not be sufficiently bonded to the initial surface. Condition at time of treatment and initial existing surface preparation are attributes of surface condition. A weight of 0.7 was assigned to the condition at time of treatment because it has three rating criteria associated with it. Initial existing surface preparation was assigned a weight of 0.3 as it has only one rating criterion.

*Condition at time of treatment*

Information recorded under this attribute describes how clean the pavement is, the amount of moisture on the surface, and the pavement temperature during the application of the treatment. The weights assigned to the sub-attributes are 0.4 for how clean, 0.3 for moisture, and 0.3 for pavement temperature. The higher weight assigned to how clean indicates that it is slightly more critical than the other two sub-attributes.

## How clean

A clean surface provides the best condition for strong bonds to develop between the binder and the surface. The application of binder to a dirty surface results in poor bonding since the binder adheres to the dirt instead of the surface, and the binder and cover aggregate may break away from the pavement surface at some future time. How clean has possible ratings of clean, mostly clean, somewhat dirty, and dirty, with clean assigned to the highest rating, and proceeding down to dirty, which received the lowest rating.

## Moisture

The presence of moisture on the surface may slow the curing process. Excessive moisture on the surface may also interfere with the bond between the surface and the binder if there is enough water present to form a barrier between them. The rating criteria for this attribute are dry, mostly dry, somewhat moist, and wet. The highest rating was assigned to dry. The ratings decrease as the surface moisture increases, thus, wet received the lowest rating.

## Pavement temperature

The temperature of the binder will almost immediately assume the temperature of the pavement surface to which it has been applied. Low pavement temperatures may slow the curing process and may also cause the binder to become stiff. Stiffening of the binder results in poor bond development since the binder will not flow with the movement of the aggregate during the rolling process. High pavement temperatures may cause the emulsion to skim or break prior to the completion of rolling. Pavement temperature has ranges of below 60°F, 60 to 80°F, 81 to 110°F, 111 to 130°F, and above 130°F. The 81 to 110°F range received the highest rating because problems associated with low and high temperatures are not present. The 60 to 80°F range received the second best rating; however, slow curing problems associated with low temperatures might be noticed. The third best rating was assigned to the 111 to 130°F range. Problems associated with high pavement temperatures are possible within the 111 to 130°F range. The lowest ratings were

assigned to below 60°F and above 130°F. Application should not take place if the pavement temperature is below 60°F due to low temperature problems. When the surface temperature is above 130°F, the emulsion may break prematurely, and the binder may not develop adequate adhesion with the cover aggregate to hold it in place.

### *Initial existing surface preparation*

The four types of surface preparation are: none, sweep only, cold mill, and shot blast. A chip seal will adhere best to a surface which is clean and slightly rough. If the surface is dirty, the binder will stick to the dirt, and the binder and cover aggregate may break away from the pavement surface at some future time. A slightly rough surface provides more surface area for the binder to develop adhesion with. A very rough surface would cause the binder to pool in the depressions and flow from the high points. This could cause an uneven binder distribution with some cover aggregate buried in the pools and some aggregate lost from the high points. The highest rating was assigned to shot blast, while cold mill and sweep only are rated only slightly less than shot blast. Cold mill is preferred to sweep only. The lowest rating was assigned to none.

## Equipment

Three types of equipment are considered, all of which are very important for the chip seal application. They are the distributor, the aggregate spreader, and the rollers. These three types of equipment are the attributes of equipment. The distributor was assigned a weight of 0.4, while the aggregate spreader and roller attributes were each assigned a weight of 0.3. The distributor was assigned a higher weight because of the difficulties often encountered with it and because of the importance of getting correct distribution of the binder.

### *Distributor*

The role of the distributor is very important. It must be able to apply an even coat of bituminous material at the correct rate to assure the aggregate will be properly bonded to the existing surface. The distributor has many important instruments, such as a bitumeter, a tachometer, a heater, and a thermometer, which need to be working to help the operator apply the binder in the desired manner. The ten sub-attributes of the distributor are: cleaned before use, equipped with a bitumeter that registers in feet/minute, bitumeter visible to operator, bitumeter used by operator, equipped with a tachometer on the pump, tachometer visible to operator, tachometer used by operator, equipped with a heater, equipped with a full circulatory system including the spraybar, and thermometer visible to operator. Each of these sub-attributes was assigned a weight of 0.10. The rating criteria for each of them is yes, usually, sometimes, and no. Due to the nature of each of these sub-attributes, the highest rating is always assigned to yes, the second highest rating to usually, the next to lowest rating is assigned to sometimes, and the lowest rating is assigned to no.

## Cleaned before use

It is necessary to clean the distributor before use. Many different types of binders are used. Most often, cutback asphalts and emulsified asphalts are used, and there are several types of these. Contamination of the binder with material left in the distributor can be disastrous to performance of the binder. Therefore, it is important to clean the distributor of any leftover material before filling it with the material for a new job.

## Equipped with a bitumeter that registers in feet/minute

The bitumeter is an instrument used by the operator to maintain the proper vehicle speed. A speed is selected based on the pump speed, spraybar width, and desired spreadrate. Maintaining the correct vehicle speed is necessary to achieve the desired binder application rate. Thus, the distributor should be equipped with a bitumeter.

## Bitumeter visible to operator

The bitumeter should be visible to the operator. Being able to monitor the vehicle speed and maintain the correct speed is very important. Thus the operator needs to be able to watch the bitumeter during application of the binder.

## Bitumeter used by operator

As mentioned above, the bitumeter is an instrument which measures the speed of the distributor in feet per minute. It is important that the operator uses this tool to assure that the proper speed is maintained during application of the binder to achieve the desired application rate.

## Equipped with tachometer on the pump

The pump tachometer measures the speed of the pump. A selected pump speed which corresponds with the desired spread rate, spraybar width, and vehicle speed must be maintained. The tachometer is used to monitor the pump speed and maintain it at the proper rate.

## Tachometer visible to the operator

The operator should be able to view the tachometer during application. Maintaining it at the correct speed is important to attain the proper application rate.

### Tachometer used by operator

The operator should use the tachometer to maintain the proper pump speed.

### Equipped with a heater

A heater on the distributor is necessary to maintain the binder at the desired temperature. If the binder becomes too cool, it can clog the spray nozzles and may not adhere as readily to the surface and/or the aggregate. If an emulsion is heated too much, it can break in the distributor.

### Equipped with a full circulatory system including the spraybar

It is important to have a full circulatory system including the spraybar. This keeps the binder circulating and does not allow it to cool in the spraybar. If the binder cools in the spraybar, it can clog the spray nozzles.

### Thermometer visible to the operator

A desired application temperature is determined for the binder. The operator needs to be able to monitor the temperature to insure it is at the desired application temperature. Temperatures too high could have adverse effects on the binder by causing it to break too soon, while temperatures too low could cause the binder to clog the spray nozzles.

## *Aggregate Spreader*

The aggregate spreader is used to spread the aggregate on the road surface after the binder has been applied. The aggregate spreader should be able to spread a layer of aggregate that completely and evenly covers the surface. It is not desirable to apply excessive amounts of aggregate as this would not be economically feasible. In addition, excess stones displace set stones when traffic is applied. If inadequate aggregate is applied, bare spots will appear. Thus, the aggregate spreader should be capable of applying a layer that completely and uniformly covers the entire surface, and is one stone thick. The three most commonly used aggregate spreaders are the self-propelled, truck-attached mechanical spreader, and the tail gate spreader. The rating for the aggregate spreader is based on which type is used.

The self-propelled aggregate spreader is the most preferred, and received the highest rating. Because it has its own motor, it is better able to maintain a constant speed and deliver an even spread. It is also more accurate, because the driver is facing the direction the spreader

is travelling and has greater control on the direction of the spreader. The spreader box width can be adjusted by opening or closing gates on the spreader box. A mechanical feeder device helps deliver a uniform spread across the lane width (22).

The truck-attached mechanical spreader received the second-best rating. This is a hopper which attaches to the back of a truck. The aggregate flows from the truck into the hopper and is spread onto the surface. A mechanical feeder device helps to deliver a uniform spread across the lane width (22). The truck driver must control the speed and the direction of the spreader by driving the truck in reverse. This type of spreader is not as accurate as the self-propelled, but is better than the tailgate spreader.

The tail gate spreader received the lowest rating, because it is the least accurate of the three types of spreaders, and this type of spreader does not have a mechanical feeder device. The truck driver must also control the speed and the direction of the spreader by driving the truck in reverse. The tailgate spreader is attached to the back of a dump truck. The rate of application is controlled by the opening of the truck tailgate and the speed of the truck.

### *Rollers*

Rollers are used to seat the aggregate after it has been spread on the binder. The roller applies pressure to the aggregate and pushes the aggregate into the binder, helping create the desired bond between the aggregate and the binder. The two sub-attributes for rollers are: roller used for seating aggregate, and tire pressures are correct and uniform. Both of these received a weight of 0.5.

### Rollers used for seating aggregate

This refers to the type of roller used to seat the aggregate. The three rating criteria which have been listed are pneumatic, steel wheel, and none.

A pneumatic roller consists of inflated rubber tires which push the aggregate into the binder. Each roller has several tires across the width of the roller. This type of roller is considered best because it is capable of seating the aggregate in slight depressions, and it will not crush the aggregate. The highest rating is assigned to the pneumatic roller.

A steel wheel roller will also help to seat the aggregate. However, this type of roller may crush the aggregate and is not capable of seating the aggregate in depressions. This type of roller is better than no roller at all, but it receives only a medium rating.

The third criteria, none, received the lowest possible rating because rolling immediately after application of the aggregate is necessary to seat the aggregate and develop the desired bond.

## Tire pressures are correct and uniform

This refers to the tire pressures of the pneumatic roller mentioned above. A tire containing high pressure will apply more force to the aggregate than a tire containing a low pressure. The result of using a roller having tires with varying pressures may be a surface which has some aggregate seated well, and some aggregate not seated very well. Therefore, all tires should contain the same pressure to get a uniform seating of the aggregate across the width of the lane. The rating criteria for this are yes, usually, sometimes, and no. The highest rating was assigned to yes, and the lowest was assigned to no.

# Construction

The construction rating criteria is divided into three attributes: application of binder, application of aggregate, and rolling. Application of binder was assigned the highest weight, 0.4, because of the importance of getting the correct distribution of the binder. Application of aggregate and rolling each received a rating of 0.3.

## *Application of the binder*

The seven sub-attributes of application of the binder are: application temperature of binder, building paper used at beginning and end of treatment, application rate of binder, uniform spray applied, atomization noticed, streaking of the asphalt noticed, and handsprayer used to touch up missed spots. The highest weight, 0.25, was assigned to application rate of binder, as this is the single most important sub-attribute. Application temperature of binder, uniform spray applied, and streaking of the asphalt noticed each received a weight of 0.20. This is also a relatively high weight which indicates the importance of these sub-attributes. Handsprayer used to touch up missed spots received a weight of 0.08, atomization noticed received a weight of 0.05, and building paper used at the beginning and end of treatment received a weight of 0.02. The low weights received by these last three sub-attributes reveal they are not as critical as the others.

## Application temperature of the binder

The application temperature of the binder is an important detail. If the binder is too hot, it can cause the emulsion to break early. If the binder is too cool, it can clog the spray nozzles and may not adhere to the surface or the aggregate as well as it would at the proper temperature. Several temperature ranges have been listed, and the best one to describe the actual temperature based upon the desired temperature is chosen. The ranges are ±2, ±6, ±10, ±15, and >±15°F. The closer the temperature is to the desired temperature, the higher the rating it will receive. Therefore the ±2°F range receives the highest rating, while the >±15°F receives the lowest rating.

## Building paper used at beginning and end of treatment

Building paper is used to give a smooth construction joint, and also catches any extra binder which might drip from the spraybar at the beginning or end of the binder application. Although the lack of use will not damage the entire job, it can cause problems at the construction joints at the beginning and end of the work section. Failure to use the paper reduces the rating, but not nearly as much as an item which affects the entire job. The rating criteria are yes, usually, sometimes, and no. The highest rating was assigned to yes and the lowest to no.

## Application rate of binder (gallons/square yard)

This is a measure of the amount of binder applied to the surface. Applying the correct amount is extremely important. Too much binder will cause the seal to bleed. A loss of cover aggregate will generally occur if inadequate binder is placed. Best results are expected at the specified rate. Ranges for the actual application rate have been selected with reference to the specified rate. The ranges are: $\pm 0.02$, $\pm 0.04$, $\pm 0.06$, $\pm 0.10$, and $> \pm 0.10$ gallons/square yard. The range which best describes the actual application rate is chosen. Higher rating values are given to values closer to the specified rate. Thus, the $\pm 0.02$ range received the highest rating, while the $> \pm 0.10$ range received the lowest rating.

## Uniform spray applied

This refers to the evenness of the applied binder. If the distributor's spraybar or nozzles are not properly adjusted, the spray of binder will be uneven. This would mean that some areas of the road would receive an excess of binder, while other areas would receive too little. An excess of binder may cause the pavement to bleed, while not enough binder might lead to loss of aggregate. It is possible to apply the binder at the proper rate but not have a uniform spray. Uneven application could cause some areas to bleed while others would lose the cover aggregate. It is best to have a uniform spray. The rating for yes received the highest value, and no received the lowest.

## Atomization noticed

Atomization occurs when the spray of binder is so fine that the tiny particles drift in the wind. This is an undesirable condition which could cause improper and uneven application rates. Therefore, the highest rating value is given for no, and the lowest value is given for yes.

## Streaking of the asphalt noticed

Streaking describes a condition where bare or nearly bare lines or spots are left on the surface. This is usually caused by a clogged nozzle, or a nozzle that is not adjusted properly. Aggregate will not adhere to the surface where streaking has occurred due to a lack of binder. Streaking is a condition which should be avoided. An answer of yes to this question receives a low rating value, while an answer of no receives a high rating value.

## Handsprayer used to touch up missed spots

The handsprayer is a short spraybar which is attached to the distributor by a long hose. It is operated by hand and used to apply binder to areas missed by the distributor. Use of the handsprayer is only required if the distributor misses an area, or for small places not feasible for the distributor, such as finishing intersections and widening transitions. The highest rating was assigned to yes and the lowest to no.

### *Application of Aggregate*

The six sub-attributes which fall under application of aggregate are: range of rate compared to target rate, 0.20; aggregate is spread uniformly, 0.20; streaking of aggregate is noticed, 0.15; time between application of binder and spreading of aggregate, 0.20; aggregate is clean, 0.15; and moisture condition of aggregate, 0.10.

## Range of rate compared to target rate

The actual rate of aggregate applied is compared to the specified or target rate. The target rate is that amount of aggregate determined in mix designs to cover the surface by leaving as few voids as possible but being only one layer of stone thick. Excessive aggregate is not desired as this can cause crushing of the aggregate if stones are on top of one another. Excessive aggregate can also cause displacement of stones which are already set in the binder, as the extra stone is pushed between the embedded stones. When set stones are displaced, the binder attached to the stone is also removed. This leaves insufficient binder available to hold the new stone which displaced the original stone. The new stone may be easily removed by traffic or by brooming. The binder on the displaced stones also tends to stick to vehicle tires creating windshield and headlight damage due to thrown stones. Not having enough aggregate can leave bald spots on the surface and/or give a ragged surface. These conditions can cause the surface to be rough, and may cause it to have a low skid resistance due to the lack of sufficient cover aggregate. Ranges have been given for the rating criteria as follows: $\pm 1$, $\pm 2$, $\pm 4$, $\pm 6$, and $> \pm 6$ pounds/square yard. The most desired range is $\pm 1$ pounds/square yard, and it received the highest rating because it is almost exactly the required rate. As the range increases in size, the ratings decrease. The lowest rating was assigned to the largest range, $> \pm 6$ pounds/square yard.

## Aggregate is spread uniformly

This refers to the evenness of the applied aggregate. It is possible to apply the asphalt at the proper rate, but not have a uniform cover of aggregate. This could happen if the aggregate spreader was not adjusted properly across its width, or if the spreader is not maintained at a constant speed. A uniform spread is desired, thus the highest rating is assigned to yes while the lowest is assigned to no.

## Streaking of aggregate is noticed

Streaking of aggregate occurs when a portion of the spreader becomes blocked, and the flow of aggregate is interrupted in a small area. This is seen as a bare strip on the surface as the asphalt is not covered by the aggregate. Streaking is usually caused by deleterious material in the aggregate and is an undesirable condition. The highest rating is given for no and the lowest rating is given for yes.

## Time between application of binder and spreading of aggregate

It is important to spread the aggregate and complete the rolling as soon as possible after the binder has been applied. This provides the best condition for the aggregate to become attached to the binder. Prolonged periods between the application of the binder and spreading of the aggregate may allow the binder to skim or break prior to the aggregate being seated. The ranges for the rating criteria are $<10$ seconds, 10 to 30 seconds, 30 to 60 seconds, 60 to 90 seconds, and $>90$ seconds. The $<10$ seconds range received the highest rating. Lower ratings were assigned to ratings as the range of time increased. The lowest rating was assigned to the range $>90$ seconds.

## Aggregate is clean

A stronger bond can be developed between the binder and clean aggregate than with aggregate which is dirty. Poor bonds develop with dirty aggregate because the asphalt bonds to the fine material surrounding the aggregate instead of the stone. Loss of aggregate will occur as the result of poor bonding. The highest rating was assigned to clean because the strongest bonds will develop with clean aggregate. The second highest rating was assigned to only slightly dirty as this condition will also generally develop a good bond. A condition of somewhat dirty indicates that there is enough dirt present in the aggregate to interfere with the asphalt developing a good bond with the aggregate, and this condition received a mediocre rating. The lowest rating was given to the condition referred to as dirty. This indicates that significant amounts of dirt are present and bonding will definitely be hindered.

## Moisture condition of aggregate

The moisture condition of the aggregate can affect the strength of the bond between the binder and the aggregate. The following six terms are used to describe the moisture condition of the aggregate: very dry, dry, only slightly damp, somewhat damp, slightly wet, and wet. Very dry, dry, and only slightly damp aggregates will absorb water from the emulsion. As the water from the emulsion is absorbed by the rock, the asphalt is pulled to the surface of the rock. This absorption process can be beneficial to bonding, however dry and very dry aggregates may absorb too much water from the emulsion and cause it to break too soon. Only slightly damp is the best condition because the aggregate will not add water to the emulsion, and is unable to absorb enough to cause breaking problems. Aggregates which are somewhat damp, slightly wet, or wet may not develop a strong bond due to the excess water in the stones. The excess water in the stone can form a film between the binder and the aggregate preventing proper bonds from developing. The highest rating is assigned to only slightly damp. Ratings decrease on either side of the only slightly damp condition. The second highest rating was assigned to dry. The middle range of ratings were assigned to somewhat damp, very dry, and slightly wet. Wet received the lowest rating.

### *Rolling*

The rolling process pushes the aggregate into the binder. This process helps to develop a stronger bond between the aggregate and binder as more binder attaches itself to the aggregate. Rolling also causes stones which are standing on edge to lay flat in the binder, thus developing stronger bonds due to increased surface area in contact between the aggregate and binder. The seven sub-attributes and their weights are: rollers operate in a longitudinal forward direction, 0.10; rollers exceed speeds of 5 miles per hour, 0.15; final roller coverage is in direction traffic will travel, 0.10; rollers cover entire lane width in single pass, 0.20; time between spreading of aggregate and beginning of rolling, 0.15; number of coverages by roller(s), 0.15; and time required to complete rolling after aggregate is spread, 0.15.

## Rollers operate in a longitudinal forward direction

The rollers should operate in a longitudinal forward direction. This is the fastest and easiest way to cover the full lane. It also helps orient the aggregate in the direction of tire travel. Turning on the unrolled surface can dislodge the cover aggregate. The highest rating for this criteria was assigned to yes.

## Rollers exceed speeds of 5 miles per hour

Rollers operating at speeds greater than 5 miles per hour may pick the aggregate up on the tires and displace it. This causes problems when the aggregate is removed from its original

position and falls on the surface with the sticky asphalt side turned upwards. The displaced aggregate may attach itself to the wheels of additional roller coverages or traffic, leading to problems caused by "flying" aggregate. It may cause more aggregate to be displaced or possibly crushed. Roller operating speeds greater than 5 miles per hour are not desired. The highest rating is assigned to no and the lowest is assigned to yes.

## Final roller coverage is in direction traffic will travel

Making the final roller coverage in the direction that the traffic will travel leaves the aggregate oriented in a position that is less likely to be displaced by traffic. This should help to reduce the loss of aggregate. The highest rating is assigned to yes and the lowest rating to no.

## Rollers cover entire lane width in single pass

Seating the aggregate as soon as possible after it has been spread increases the likeliness of developing a good bond. When the rollers are able to cover the entire lane width, all of the aggregate can be rolled immediately behind the aggregate spreader. Therefore it is best to have rollers capable of covering the entire lane width in a single pass. The highest rating was assigned to yes and the lowest to no.

## Time between spreading of aggregate and beginning of rolling

The rolling process seats the aggregate in the binder. Bonding begins soon after the aggregate has been spread; therefore, it is important to seat the aggregate as soon as possible. This will also avoid breaking bonds which might develop if rolling is delayed. Four time ranges have been given ratings. The highest rating is given to the range $< 10$ seconds. The second best range is 10 to 30 seconds. The third best range is 31 to 60 seconds, and the range with the lowest rating is $> 60$ seconds.

## Number of coverages by roller(s)

Each successive coverage by the rollers helps to seat the aggregate more densely. Three coverages are usually sufficient; however, more than three are preferred. Five different ratings have been listed. The highest rating is given to $> 3$ coverages. The rating for 3 coverages is also very high. Ratings decrease slightly for 2 coverages, and decrease significantly for only one coverage. The lowest rating is given for 0 coverages.

### Time required to complete rolling after aggregate is spread

Rolling should be completed as soon as possible after the aggregate is spread. Rolling is more effective when completed early because the binder becomes stiff as it cures. Four time ranges have been given ratings. The highest rating was assigned to <5 minutes. The range of 5 to 15 minutes also received a high rating. A mediocre rating was assigned to the 15 to 30 minute range. The lowest rating was assigned to >30 minutes.

## Curing / Traffic Control

This main attribute records information pertaining to the time allowed for the seal coat to cure and the traffic control. The seven attributes and their weights are: estimated time allowed for seal coat to cure after rolling, prior to traffic application, 0.20; traffic kept off of surface until rolling completed, 0.20; length of time traffic was controlled after opening, 0.15; length of time between finish of rolling and brooming, 0.10; amount of aggregate removed by broom, 0.10; maximum speed allowed during traffic control, 0.15; and method used to control traffic speed, 0.10.

### *Estimated time allowed for seal coat to cure after rolling, prior to traffic application*

Applying traffic to the surface before adequate bonding takes place may result in loss of aggregate, since the traffic may remove the stones. The following six time ranges have been defined as rating criteria: 0 to 0.5 hours, 0.5 to 1.0 hours, 1 to 2 hours, 2 to 4 hours, 4 to 6 hours, and >6 hours. Since greater bonding is likely to occur as curing time increases, the highest rating was assigned to the >6 hours curing period. Lower ratings were assigned as the curing periods decreased. The lowest rating was assigned to the shortest curing period, 0 to 0.5 hours.

### *Traffic kept off of surface until rolling completed*

Traffic on the surface before rolling is completed could displace the aggregate. This causes problems, as the displaced aggregate is likely to stick to the tires of the rollers and cause other stones to be displaced. Traffic should be kept off of the surface until rolling is completed. The highest rating was assigned to yes and the lowest to no.

### *Length of time traffic controlled after opening*

Vehicles travelling at high rates of speed are more likely to remove aggregate from the surface. It is important to control the speed of the traffic and keep it relatively low to avoid this loss. The following six time ranges are used as the rating criteria: 0 to 0.5 hours, 0.5 to 1.0 hours, 1 to 2 hours, 2 to 4 hours, 4 to 6 hours, and >6 hours. Since increased curing

time increases the bond, the longest period of traffic control listed, >6 hours, received the highest rating. Ratings decrease as the curing time decreases. The lowest rating was assigned to 0 to 0.5 hours.

Another factor to consider is the length of time between finish of rolling and brooming. The broom is used to remove loose excess stones from the surface before traffic is applied. This reduces the chance of windshield damage caused from stones thrown by other vehicles. Increased curing time helps stronger bonds to develop between the binder and aggregate. These stronger bonds are needed to avoid removal of the aggregate by the broom and the traffic. The following six time ranges are used for rating criteria: 0 to 0.5 hours, 0.5 to 1 hours, 1 to 2 hours, 2 to 4 hours, 4 to 6 hours, and >6 hours. The highest rating was assigned to >6 hours. Rating values decrease as curing time decreases. The lowest rating was assigned to 0 to 0.5 hours.

### *Amount of aggregate removed by broom*

The purpose of the broom is to remove the loose stones from the surface to avoid windshield damage to the road users. Four ranges have been defined to describe the amount of aggregate removed. The ranges are: none, very little, moderate, and significant. The highest rating was assigned to none. The second highest rating was assigned to very little. Both of these indicate good bonding between the aggregate and the binder as well as the proper application rate. A low rating was assigned to moderate, and the lowest to significant. Both of these indicate poor bonding between the aggregate and the binder or an excessive aggregate application rate.

### *Maximum speed allowed during traffic control*

This refers to the maximum vehicle speed allowed on the surface during traffic control. Slower vehicle speeds reduce the amount of aggregate removed by the traffic. The following four ranges have been defined: <20 miles per hour, 20 to 30 miles per hour, 30 to 40 miles per hour, and >40 miles per hour. The highest rating was assigned to <20 miles per hour. Rating values decrease for the ranges as the speed increases. The lowest rating was assigned to >40 miles per hour.

### *Method used to control traffic speed*

Some methods of traffic control are more effective than others. The four methods used as rating criteria are: pilot vehicles, flagmen, signs, and none. Pilot vehicles receive the highest rating. This is a vehicle which leads the traffic, forcing all other vehicles to travel

at the desired rate of speed. Flagmen received the second highest rating. They are effective at slowing vehicles down, but are unable to keep the vehicles at or below the desired rate of speed. Signs received a low rating because drivers often disregard them. The lowest rating was assigned to none.

# 5

# Slurry Seal Attributes and Rating Criteria

Descriptions of the various branches of the slurry seal rating tree are given in this chapter. Rating criteria for the slurry seal treatment are divided among four main attributes: environmental, surface condition, construction, and curing/traffic control. Each of these four main characteristics have attributes and sub-attributes which are used to ultimately produce an overall rating of the slurry seal surface treatment application process.

The main attributes, attributes, and sub-attributes are described separately. Each one has an explanation of what it represents and justification for the weight assigned to it. Justification for the ratings assigned to the rating criteria and the effect they have on the surface treatment are also listed.

The descriptions begin with environmental, which is the first main attribute. All attributes, sub-attributes, and rating criteria related to environmental are then described. The same procedure is followed for the other three main attributes and their corresponding attributes, sub-attributes, and rating criteria.

The following weights were assigned to the main attributes: environmental, 0.12; surface condition, 0.12; construction, 0.66; and curing/traffic control, 0.10. The weights are based on the expected relative importance of the main attributes and the number of rating criteria within them. The large number of rating criteria associated with the construction attribute and the importance of proper construction warrant the higher weight assigned to it.

## Environmental

The environmental rating criteria is divided into two attributes; date of work and ambient conditions. These are important items to be considered for a slurry seal, because warm weather and long curing periods help stronger bonds to develop between the seal and the existing surface. Date of work was assigned a weight of 0.3, and ambient conditions was

assigned a weight of 0.7. The higher weight assigned to ambient conditions is attributed to the three rating criteria associated with it compared to only one for date of work, and the importance of temperature to the immediate success or failure of the treatment.

### *Date of work*

This refers to the time of year in which the work is performed. It is important for considering the impact of curing conditions expected based on average climatic conditions. Long curing periods during warm weather are preferred because this allows maximum time for the slurry seal to bond to the existing pavement surface. For most climates, the best time is the period of May 15 - August 31. The climatic conditions during that period should provide the warm temperature and adequate curing periods prior to cold weather. Work performed before May 15 is expected to have cooler nights but longer curing periods than work done after August 31, and is given a slightly higher rating value because of the longer curing periods. However, in both of these time periods, the evening temperatures and temperatures during the days immediately following the application could be much cooler than desired. In some areas, such as those with very hot climates, this season will need to be changed to avoid the hottest periods.

### *Ambient Conditions*

Air temperature and relative humidity are sub-attributes of ambient conditions. Air temperature received a weight of 0.8 and relative humidity received a weight of 0.2. The higher weight for air temperature is due to the fact it has two rating criteria compared to one for relative humidity, and because temperature has a greater impact on the curing process than relative humidity.

### Air temperature

Both the low and the high air temperature are recorded under the air temperature sub-attribute. Temperature plays an important role in regard to the curing rate and the bond developed between the seal and the surface. Low temperatures slow the curing process as well as the separation of water from the slurry. High temperatures may cause the slurry to skim or break in the spreader box. The weight assigned to low air temperature (0.6) is higher than the weight for high air temperature (0.4) because low temperatures have more affect on the development of strong bonds.

Low air temperature is the lowest temperature encountered during the construction process. This will usually be the temperature at the beginning of the work, although cooler temperatures may occur after work has begun. Ranges of below 60°F, 60 to 70°F, and above 70°F are used to rate this sub-attribute. Below 60°F received the lowest rating because low temperatures slow the curing process, which retards the development of the

bond between the seal and the surface. Adequate bonding is expected when the low temperature is between 60 and 70°F, but it received a rating slightly less than the best condition which is above 70°F.

High air temperature is the highest temperature encountered during the construction process. The ranges given for high air temperature are below 70°F, 70 to 95°F, 96 to 110°F, and above 110°F. Slow curing would be expected if the high air temperature is below 70°F, and it has been assigned a relatively low rating. The highest rating was assigned from 70 to 95°F because it is the best condition for curing and bonding. The 96 to 110°F range was also assigned a high rating, but is not considered to be the best condition because the high temperatures could cause the slurry to break prematurely. The lowest rating belongs to the above 110°F range since temperatures this high may cause the emulsion to break in the spreader box.

### Relative humidity

The relative humidity effects the evaporation rate of the water in the slurry. Low humidity will increase the evaporation rate, and may cause the slurry to break early. High relative humidity can also be a hindrance, as the water may be slow to evaporate after the slurry breaks. The following three ranges for relative humidity have been defined: below 40 percent, 40 to 80 percent, and above 80 percent. Below 40 percent received the lowest rating as it could cause the slurry to break early. The 40 to 80 percent range received the highest rating because it will not cause early breaking of the slurry, or significantly delay the evaporation of the water after the slurry breaks. Above 80 percent has a rating between the other two. Above 80 percent humidity may delay the curing by retarding water evaporation after the slurry breaks.

## Surface Condition

The pavement surface must be properly prepared and in good condition to obtain strong bonds between the slurry seal and the old surface. Failure to do this will result in loss of the slurry seal because it will not be sufficiently bonded to the initial surface. Condition at time of treatment and initial existing surface preparation are attributes of surface condition. A weight of 0.7 was assigned to condition at time of treatment because it has a three rating criteria associated with it. Initial existing surface preparation was assigned a weight of 0.3, as it has only one rating criterion.

### *Condition at time of treatment*

Information recorded under this attribute describes how clean the pavement is, the amount of moisture on the surface, and the pavement temperature during the application of the

treatment. The weights assigned to the sub-attributes are 0.4 for how clean, 0.3 for moisture, and 0.3 for pavement temperature. The higher weight assigned to cleanliness indicates that it is slightly more critical than the other two sub-attributes.

## How clean

A clean surface provides the best condition for strong bonds to develop between the slurry and the surface. The application of a slurry seal to a dirty surface results in poor bonding as the seal adheres to the dirt instead of the surface and may break away from the pavement surface at some future time. How clean has possible ratings of clean, mostly clean, somewhat dirty, and dirty. Clean was assigned the highest rating, mostly clean received the second best rating, somewhat dirty received a low rating, and dirty received the lowest rating.

## Moisture

The presence of excessive moisture on the surface may slow the curing process, and may also interfere with the bond between the surface and the seal if there is enough water present to form a barrier between them. The rating criteria for this attribute are dry, mostly dry, somewhat moist, and wet. The highest rating was assigned to mostly dry. Dry received a slightly lower rating because the surface will absorb water from the slurry if it is not pre-wet by the slurry machine. Somewhat moist received a slightly lower rating than the best condition because of the problems associated with excessive moisture. The lowest rating was assigned to wet.

## Pavement temperature

The temperature of the slurry will almost immediately assume the temperature of the pavement surface to which it has been applied. Low pavement temperatures may slow the curing process. High pavement temperatures may cause the slurry to break before it can be spread. Pavement temperature has ranges of below 60°F, 60 to 80°F, 81 to 110°F, 111 to 130°F, and above 130°F. The 81 to 110°F range received the highest rating because problems associated with low and high temperatures are not present. The 60 to 80°F range received the second best rating; however, slow curing problems associated with low temperatures might be noticed. The third best rating was assigned to the 111 to 130°F range. Problems associated with high pavement temperatures are possible within the 111 to 130°F range. The lowest ratings were assigned to below 60°F and above 130°F. Application should not take place if the pavement temperature is below 60°F due to low temperature problems. When the surface temperature is above 130°F, the slurry may break prematurely.

*Initial existing surface preparation*

The four types of surface preparation are: none, sweep only, cold mill, and shot blast. A slurry seal will adhere best to a surface which is clean and slightly rough. If the surface is dirty, the seal will stick to the dirt, and may break away from the pavement surface at some future time. A slightly rough surface provides more surface area for the seal to develop adhesion with. A very rough surface would require more slurry material to fill the depressions and would not be economical. The highest rating was assigned to shot blast, while sweep only is rated only slightly less than shot blast. Sweep only is preferred to cold mill because the cold mill surface may be excessively rough. The lowest rating was assigned to none.

## Construction

The construction rating criteria is divided into four attributes. The attributes and their weights are: aggregate condition, 0.08; machine details, 0.54; application of slurry, 0.30; and surface texture, 0.08. The high weights assigned to machine details and application of slurry are attributed to the large amount of rating criteria associated with them and their importance to the construction of a successful slurry seal.

### Aggregate Condition

The sub-attributes, and their weights, for aggregate condition are: cleanliness, 0.7; and moisture, 0.3. It can be seen from the assigned weights that cleanliness is more important than moisture. This is because the slurry machine can compensate for the moisture by the amount of pre-wet water added to the aggregate as it enters the mixing chamber.

### Cleanliness

The aggregate should be free of any deleterious materials such as excess fines, grass, paper, glass, or any other foreign substance. The presence of deleterious materials in the aggregate may hinder cohesion of the slurry material, and may also reduce the bond between the surface and the slurry. This will result in a material which is likely to be removed by traffic. It may also cause streaking if debris inside the spreader box is unable to pass beneath the rear squeegee and is dragged by the squeegee. The highest rating was assigned to clean. The second highest rating was assigned to only slightly dirty. Somewhat dirty received a low rating. The lowest rating was assigned to dirty.

## Moisture

The amount of moisture present in the aggregate must be taken into consideration. Aggregates which are dry or very dry will absorb water from the emulsion and may cause it to break. However, the slurry machine should be capable of pre-wetting the aggregate upon its arrival to the mixer. Pre-wetting will usually prevent the aggregate from absorbing water from the emulsion, thus the rating for dry and very dry aggregates are fairly high. When too much moisture is present in the aggregate, the excess moisture may cause the emulsion to become unstable. The bulking effect of the moisture on the aggregate must also be considered, and the volume feed gate of the machine adjusted for it. This is because the amount of dry aggregate in any given volume decreases as the moisture increases(9). The best condition is when the aggregate is only slightly damp, so it received the highest rating. A condition of somewhat damp received the second highest rating, and dry received the third highest. The fourth best rating was assigned to two different conditions, very dry and slightly wet. A very low rating was assigned to wet.

## *Machine Details*

The slurry seal machine is a very important piece of equipment. The machine carries all necessary materials, and is responsible for mixing the aggregate, emulsion, mineral filler, and water in correct proportions to produce a stable slurry(9). It also spreads the slurry on the pavement surface at a selected thickness. The following twenty sub-attributes are used to rate the performance of the slurry machine: continuous flow of mixing; accurately apportions mix components; discharges thoroughly mixed product continuously; aggregate pre-wet immediately prior to mixing with emulsion; ingredients thoroughly blended in the mixing chamber; metering device introduces predetermined proportion of mineral filler into mixer; mineral filler fed at same time and location as the aggregate; fines feeder provided for mineral filler; fog spray system used prior to seal; equipped with a mechanical type squeegee distributor; flexible rear strikeoff kept in contact with pavement surface; working steering device on spreader box; spreader box kept clean and free of buildup; was spreader box overloaded; is spreader box evenly filled at all times; is any lumping, balling, or unmixed aggregate noticed; is segregation of the emulsion and aggregate fines from the coarse aggregate noticed; slurry remains well mixed in spreader box; is breaking of emulsion noticed in spreader box; buildup of material along longitudinal and transverse joints. Each sub-attribute received a weight of 0.5, and the rating criteria for each is listed as yes, usually, sometimes, and no.

## Continuous flow mixing

Continuous flow mixing is important to produce sufficient quantities of slurry for the pavement surface because the machine is continuously moving forward. A break in the

production of slurry while the machine is moving forward could result in a lack of slurry to adequately cover the pavement surface. Yes received the highest value, and no received the lowest.

## Accurately apportions mix components

It is extremely important that the machine accurately apportion the mix components. Failure to use the correct amount of any one of the mix components can have adverse effects on the final product. Mineral fillers are important to produce a more stable slurry, improve the gradation of the aggregate, and to help speed up or slow down the breaking of the emulsion(9). The proper amount of emulsion must be used to coat the particles of aggregate sufficiently enough with asphalt to bind them together and fill the pores. Too much emulsion would cause the surface to bleed. Water is present in the emulsion and is often present in the aggregate. Pre-wet water is used to bring the aggregate to the desired moisture level immediately prior to mixing it with the emulsion. If too much water is used, the slurry will become unstable. Not enough water may cause the slurry to break too soon. The highest rating is assigned to yes, and the lowest rating is assigned to no.

## Discharges thoroughly mixed product continuously

It is important for the slurry seal machine to discharge a thoroughly mixed product continuously. Thorough mixing is necessary for a stable slurry. A continuous discharge is necessary to provide adequate amounts of slurry because the machine is continuously moving forward. The highest rating was assigned to yes, and the lowest to no.

## Aggregate pre-wet immediately prior to mixing with emulsion

Pre-wetting the aggregate immediately prior to mixing with the emulsion is necessary to prevent the aggregate from absorbing water from the emulsion. If the aggregate absorbs too much water from the emulsion, it can cause the emulsion to break too soon. The highest rating was assigned to yes, and the lowest to no.

## Ingredients thoroughly blended in the mixing chamber

The mixing chamber is where the individual products are combined and mixed. Thorough blending in the mixing chamber is necessary to produce a uniform mixture because no further blending occurs after the mixture exits the chamber. Yes received the highest rating and no received the lowest.

## Metering device introduces pre-determined proportion of mineral filler into mixer

Mineral filler helps to produce a more stable slurry, improves the gradation of the aggregate, and can be used to speed up or slow down the breaking of the emulsion(9). It is important that the metering device introduces the pre-determined proportion of mineral filler into the mixer to obtain the best slurry. The highest rating is assigned to yes, and the lowest to no.

## Mineral filler fed at same time and location as the aggregate

The mineral filler should enter the mixer at the same time and location as the aggregate so it can be pre-wet with the aggregate and receive adequate mixing. Pre-wetting the mineral filler will prevent it from absorbing water from the emulsion which could cause the emulsion to break too soon. Yes received the highest rating and no received the lowest.

## Fines feeder provided for mineral filler

The fines feeder is a metering device which can be set to deliver a pre-determined amount of mineral filler. It is important to have a fines feeder to be certain the correct amount of mineral filler is added to the slurry mixture. The highest rating was assigned to yes, and the lowest to no.

## Fog spray system used prior to seal

The fog spray system is a spray bar used to pre-wet the pavement surface ahead of the slurry spreader box. This helps reduce friction and assists the asphalt emulsion to coat the surface more uniformly(9). Yes was assigned the highest rating and no was assigned the lowest.

## Equipped with a mechanical type squeegee distributor

The distributor, or spreader box, should be equipped with mechanical augers and squeegees(9). The augers help distribute the slurry laterally. Use of the augers is often necessary when working on slopes or when using a wide box. The purpose of the squeegees are to contain the slurry in the box, and the rear squeegee also controls the slurry thickness.

## Flexible rear strikeoff kept in contact with pavement surface

The flexible rear strikeoff, or rear squeegee, should be kept in contact with the pavement surface. This is important to keep the slurry at a uniform thickness. If the rear strikeoff is allowed to lift off of the pavement surface, the slurry seal would be thicker than where it was kept in contact. The highest rating was assigned to yes, and the lowest was assigned to no.

## Working steering device on spreader box

A steering device on the spreader box can be used to maneuver it in awkward situations such as a cul-de-sac or knuckle. The steering device is more often needed on city streets than on highways. The absence of a steering device is not usually critical, although it is best to have it just in case it is needed. The highest rating was assigned to yes, and the lowest to no.

## Spreader box kept clean and free of buildup

The spreader box should be kept clean and free of buildup. Failure to do this may result in clumps of old cured slurry contaminating the fresh slurry. Yes received the highest rating, and no received the lowest.

## Was spreader box overloaded

The spreader box should not be overloaded. Overloading would result in slurry overflowing the walls of the spreader box. Slurry overflowing the rear and side walls of the spreader box would cause the surface to be uneven. The highest rating was assigned to no, and the lowest was assigned to yes.

## Is spreader box evenly filled at all times

It is best to keep the spreader box evenly filled at all times. This will help avoid the problem of not having enough slurry in the box to cover the box's entire width. It may also help to obtain a more even thickness on the completed surface, since gravity could force more material under the rear squeegee of a full box than a near-empty box. The highest rating was assigned to yes, and the lowest to no.

## Is any lumping, balling, or unmixed aggregate noticed

Lumping, balling, or unmixed aggregate in the slurry is not desired. These items indicate poor mixing and will probably cause problems for the finished surface. Lumping and balling may cause streaking if the lumps and balls are unable to pass beneath the rear squeegee and are dragged along the surface. Unmixed aggregate will not bond with the rest of the slurry, and will be displaced by future traffic leaving depressions in the surface. No received the highest rating, and yes received the lowest.

## Is segregation of the emulsion and aggregate fines from the coarse aggregate noticed

Segregation of the emulsion and aggregate fines from the coarse aggregate indicates an unstable slurry. Correct apportioning of all ingredients and proper mixing would not yield a slurry with segregated materials. The highest rating was assigned to no and the lowest to yes.

## Slurry remains well mixed in spreader box

It is important that the slurry remains well mixed in the spreader box. Failure of this indicates a problem either in the mixing of the materials or in the slurry breaking too soon. The highest rating was assigned to yes, and the lowest to no.

## Is breaking of emulsion noticed in spreader box

Breaking of the emulsion in the spreader box is an undesirable condition. A broken slurry will not spread smoothly and may not adhere to the surface. The slurry may also crumble and be removed by traffic if breaking occurs before the slurry is spread. No received the highest rating, and yes received the lowest.

## Buildup of material along longitudinal and transverse joints

Buildup of material along longitudinal and transverse joints may cause the surface to be rough. A smooth surface provides the safest conditions for the road users, thus, and buildup along the joints is undesirable. The highest rating was assigned to no, and the lowest to yes.

*Application of slurry*

Information pertaining to the application of the slurry seal is recorded under this attribute. The six sub-attributes and their weights are: application rate of bituminous material compared to target rate, 0.15; was the application rate for bituminous material adjusted at jobsite to correct for surface condition, 0.15; application rate of aggregate compared to target rate, 0.15; application rate of mineral filler compared to target rate, 0.15; application rate of slurry mixture compared to target rate, 0.20; actual application temperature of slurry material, 0.20.

## Application rate of bituminous material compared to target rate (gallons/square yard)

Using the correct amount of bituminous material is very important. Too much could cause the slurry seal surface to bleed. Not using enough might yield a slurry which would not adhere properly and would crumble under traffic. Best results are expected at the specified rate. Ranges for the actual application rate have been selected with reference to the specified rate. The ranges are ±0.01, ±0.02, ±0.04, ±0.06, and >±0.06 gallons/square yard. The range which best describes the actual application rate is chosen. Higher ratings are assigned to the ranges which are closer to the specified rate. Therefore, the ±0.01 range received the highest rating, while the >±0.06 range received the lowest rating.

## Was the application rate for bituminous material adjusted at jobsite to correct for surface condition

A slight adjustment for the rate of bituminous material is sometimes needed. Some surfaces may absorb more binder while other surfaces require less. Yes was assigned a high rating, and no was assigned a low rating.

## Application rate of aggregate compared to target rate (pounds/square yard)

It is very important to use the correct rate of aggregate. Using too little could result in a surface which would bleed because the amount of asphalt would be too high. Too much aggregate might yield a surface which would crumble because the amount of asphalt would be too low to adequately bind the extra aggregate. Best results are expected at the specified rate. Ranges for the actual application rate have been selected with reference to the specified rate. The ranges are ±1.0, ±2.0, ±3.0, ±4.0, and >±4.0 pounds/square yard). The range which best describes the actual application rate is chosen. Higher ratings are assigned to the ranges which are closer to the specified rate. Thus, the ±1.0 range received the highest rating, while the >±4.0 range received the lowest rating.

## Application rate of mineral filler compared to target rate (pounds/square yard)

Mineral filler helps to produce a more stable slurry, can speed up or slow down the breaking of the emulsion, and can be used to improve the gradation of the aggregate(9). Using mineral filler at the proper rate is very important to obtain the best results. Ranges for the actual application rate have been selected with reference to the specified rate. The ranges are ±0.01, ±0.02, ±0.03, ±0.04, and >±0.04 pounds/square yard. The range which best describes the actual application rate is chosen. Higher ratings are assigned to the ranges which are closer to the specified rate. Thus, the ±0.01 range received the highest rating, while the >±0.04 range received the lowest rating.

## Application rate of slurry mixture compared to target rate (pounds/square yard)

Slurry application will vary with surface texture. A rough surface will require more slurry than a smooth surface. Inadequate surface sealing may result if the slurry application rate is too low. Applying excessive amounts of slurry is not cost effective. Best results are expected when the slurry is applied at the specified rate. Ranges for the actual application rate have been selected with reference to the target rate. The ranges are ±1.0, ±2.0, ±3.0, ±5.0, and >±5.0 pounds/square yard. The range which best describes the actual application rate is chosen. Higher ratings are assigned to the ranges which are closer to the specified rate. Thus, the ±1.0 range received the highest rating, while the >±5.0 range received the lowest rating.

## Actual application temperature of slurry material

This is the temperature of the slurry after it has been mixed and delivered to the spreader box. High temperatures of the slurry material should be avoided because the material may break before it is spread. Low temperatures of the slurry material can slow down the curing, and require longer periods of time for the material to break. The best temperature range is 81 to 110°F, and it received the highest rating. The second best temperature range is 60 to 80°F. It also received a fairly high rating. Application temperatures >110°F are likely to cause premature breaking, thus the rating for this range is low. The lowest rating was assigned to <60°F.

### *Surface texture*

The surface texture sub-attributes and their weights are: type of drag used, 0.4; and surface texture provided, 0.6. The resulting surface texture is more important than the type of drag used.

### Type of drag used

The drag is a device which is attached to the back of the spreader box. It drags across the surface of the slurry immediately behind the spreader box. The purpose of the drag is to level any ripples or inconsistencies of the slurry surface and leave it smooth. The most common type of drag is made of a burlap material, and it received the highest rating. Other types of materials can be used, but are not generally considered as good as burlap. The rating for other is considerably less than the rating for burlap. The lowest rating was assigned to none.

### Surface texture provided

The skid- and moisture-resistance of the surface are considered under this sub-attribute. Skid resistance is very important for safety reasons, while moisture resistance is important for preservation of the pavement. Rough and smooth are the terms used to describe skid-resistance. A rough surface has good skid resistance, while a smooth surface has a poor skid resistance. A tight surface is one which is impervious to moisture, while an open surface may be susceptible to moisture penetration. Surfaces which are somewhat smooth and tight receive the highest rating. Somewhat smooth and open was assigned the second highest rating. Rough and open was assigned the lowest rating, along with smooth and tight.

## Curing / Traffic Control

Information pertaining to the time allowed for the slurry seal to cure and the traffic control are recorded under this main attribute. The four attributes and their weights are: estimated time between application and opening section to reduced speed traffic, 0.40; maximum reduced speed allowed, 0.20; estimated time between application and opening section to full speed traffic, 0.25; and method used to control traffic speed, 0.15.

### *Estimated time between application and opening section to reduced speed traffic*

This is the length of time the slurry is allowed to cure before traffic is permitted on it. Longer periods give the seal more time to cure. Short curing periods may yield a tender surface which is vulnerable to vehicular traffic. The following four time ranges have been defined: >3 hours, 2 to 3 hours, 1 to 2 hours, and <1 hour. The highest rating was assigned to >3 hours. The 2 to 3 hour range also received a high rating. A fairly low rating was assigned to 1 to 2 hours. The lowest rating was assigned to <1 hour.

### *Maximum reduced speed allowed*

This refers to the maximum vehicle speed allowed on the surface during traffic control. Slower vehicle speeds are preferred because they are less likely to damage the surface, and they provide an initial compaction which may be beneficial. The following four ranges have been defined: <20 miles per hour, 20 to 30 miles per hour, 30 to 40 miles per hour, and >40 miles per hour. The highest rating was assigned to <20 miles per hour. Rating values decrease for the ranges as the speed increases.

### *Estimated time between application and opening section to full speed traffic*

This is the length of time the slurry is allowed to cure before full speed traffic is allowed. Longer curing periods are preferred because the surface becomes more resistant to damage by the traffic. The following five time ranges have been defined: >8 hours, 5 to 8 hours, 3 to 5 hours, 2 to 3 hours, and <2 hours. The highest rating was assigned to >8 hours. Rating values for the ranges decrease as the curing time decreases.

### *Method used to control traffic speed*

As discussed in Chapter 4, pg. 40, some methods of traffic control are more effective than others. Of the four methods rated - pilot vehicles, flagmen, signs, and none - pilot vehicles received the highest rating, flagmen the second highest; signs were rated low because drivers often ignore them, and the lowest rating was assigned to none.

# 6

# Crack Seal Attributes and Rating Criteria

Descriptions of the various branches of the crack seal rating tree are given in this chapter. Rating criteria for the crack seal surface treatment are divided among four main attributes: environmental, surface conditions, construction, and curing. Each of the four have attributes and sub-attributes which are used to ultimately produce an overall rating of the crack seal surface treatment application process.

The main attributes, attributes, and sub-attributes are described separately. Each one has an explanation of what it represents and justification for the weight assigned to it. Justification for the ratings assigned to the rating criteria and the effect they have on the surface treatment are also listed.

The descriptions begin with environmental, which is the first main attribute. All attributes, sub-attributes, and rating criteria related to environmental are then described. The same procedure is followed for the other three main attributes and their corresponding attributes, sub-attributes, and rating criteria.

The following weights were assigned to the main attributes: environmental, 0.15; surface conditions, 0.15; construction, 0.55; and curing, 0.15. The weights are based on the expected relative importance of the main attributes and the number of rating criteria within them.

## Environmental

The environmental rating criteria is divided into two attributes: date of work and ambient conditions. These are very important items to be considered when sealing cracks because of the effects of thermal expansion and contraction of the pavement, and curing of the sealant. Date of work was assigned a weight of 0.3, and ambient conditions was assigned a weight of 0.7. The higher weight assigned to ambient conditions is attributed to the three rating criteria associated with it compared to only one for date of work.

Thermal changes in the pavement cause changes in crack widths. This occurs as pavement contraction during cool weather results in increased crack widths, whereas warm weather causes expansion of the pavement, thus decreased crack widths. Crack sealing should be avoided during periods of significant pavement contraction or expansion to prevent problems which may result from the use of too much or too little sealant. Cracks are widest during periods of significant pavement contraction, and the reservoir (crack) is capable of holding more sealant material than is necessary to adequately seal the crack. The excessive material will be squeezed from the crack when the pavement expands, resulting in tracking problems, as the material may stick to the tires of the traffic and be pulled out of the crack. On the other hand, the small reservoirs present during periods of significant pavement expansion are not capable of holding enough sealant to withstand the strain which will develop when the pavement contracts. This will usually result in the sealant breaking free from one of the crack walls.

Warm weather provides the best conditions for the development of bonds between the sealant and the pavement. Adhesion problems may occur if the sealant is applied during cold weather because the air temperature and the pavement can cause the sealant to cool too rapidly, creating strain in the sealant before adequate bonds can develop. Hot weather may also present problems as the sealant may not be able to set up within a reasonable amount of time.

### *Date of work*

This refers to the time of year in which the work is performed. It is important for considering the impact of curing conditions expected based on average climatic conditions. For most climates, the best time to seal cracks is either April 16 - June 15, or September 16 - November 15. These two rating criteria received the highest rating. The climatic conditions during these periods should provide the warm temperature and adequate curing periods for strong bonds to develop between the sealant and crack walls prior to hot or cold weather. The width of the cracks during these two periods are expected to be optimum for crack sealing as the pavement should not be experiencing either extreme contraction or expansion. The period of June 16 - September 15 received a lower rating because the high temperatures expected during that time keep the sealant from setting up, thus tracking may become a problem. Expansion of the pavement will also cause problems during this period as the crack widths are reduced and thus, not enough sealant can be placed in the crack to withstand the strain which will develop during cold weather. The lowest rating was assigned to the ranges before April 15 and after November 15. In both of these time periods, the temperatures are expected to be much cooler than desired, and problems associated with pavement contraction and rapid cooling of the sealant are likely to occur.

### *Ambient Conditions*

Air temperature and relative humidity are sub-attributes of ambient conditions. Air temperature received a weight of 0.9 and ambient conditions received a weight of 0.1. The

higher weight for air temperature is because it has two rating criteria compared to one for relative humidity, and because temperature has a greater impact on the curing process than relative humidity.

## Air temperature

Both the low and the high air temperature are recorded under the air temperature sub-attribute. Temperature plays an important role in regard to expansion and contraction of the pavement, and the development of bonds between the sealant and crack walls. Low temperatures may cause the sealant to cool before strong bonds develop, and may cause the pavement to contract. High temperatures may prevent the sealant from setting up, and may cause expansion of the pavement. The weight assigned to low air temperature (0.6) is higher than the weight for high air temperature (0.4) because low temperatures have more effect on the development of strong bonds.

Low air temperature is the lowest temperature encountered during the construction process. This will usually be the temperature at the beginning of the work, although cooler temperatures may occur after work has begun. Ranges of below 60°F, 60 to 70°F, and above 70°F are used to rate this sub-attribute. Below 60°F received the lowest rating because low temperatures rapidly cool the sealant, and may cause strain to develop within the sealant before it sets up. Adequate bonding is expected when the low temperature is between 60 and 70°F, but it received a rating slightly less than the best condition which is above 70°F.

High air temperature is the highest temperature encountered during the construction process. The ranges given for high air temperature are below 70°F, 70 to 95°F, 96 to 110°F, and above 110°F. Rapid cooling of the sealant resulting in early development of strain is expected if the high air temperature is below 70°F, thus it has been assigned a relatively low rating. The highest rating was assigned to 70 to 95°F because it is the best condition for curing and bonding. The 96 to 110°F range was also assigned a high rating, but is not considered to be the best condition because the high temperatures could cause the sealant to be slow to set up and may cause some expansion of the pavement. The lowest rating belongs to the above 110°F range, as temperatures this high are likely to cause problems with the sealant setting up and also cause the pavement to expand.

## Relative humidity

The relative humidity can have an impact on the effectiveness of crack sealing as a result of the drying effect it has on moisture in the cracks. Moisture in the crack can hinder or prevent the development of good bonds between the sealant and the crack walls. This happens because the hot sealant can cause the moisture in the crack to form steam which may form a pocket between the sealant and the crack wall. High humidity can have an impact on the curing of some sealants. The following three ranges for relative humidity have been defined: below 40 percent, 40 to 80 percent, and above 80 percent. Below 40

percent received the highest rating. Low humidity is preferred because it provides the best drying condition, thus below 40 percent received the highest rating. The 40 to 80 percent range received the second highest rating as adequate drying is expected. Above 80 percent received the lowest rating as this condition may present drying problems if there is any moisture in the crack.

## Surface Conditions

The surface conditions have a significant impact on the effectiveness of crack sealing. Condition at time of treatment and primary type of cracks are attributes of surface conditions. A weight of 0.6 was assigned to condition at time of treatment because it has three rating criteria associated with it. Primary type of cracks were assigned a weight of 0.4, as it has only one rating criterion.

### *Condition at time of treatment*

Information recorded under this attribute describes how clean the pavement is, the amount of moisture on the surface, and the pavement temperature during the application of the treatment. The weights assigned to the sub-attributes are 0.3 for how clean, 0.4 for moisture, and 0.3 for pavement temperature. The higher weight assigned to moisture indicates it is slightly more critical than the other two sub-attributes.

### How clean

A clean surface provides the best condition for crack sealing because debris on the surface may get into the cracks and contaminate the sealant or prevent the sealant from developing good bonds with the crack walls. The application of sealant to a dirty surface results in poor bonding as the sealant adheres to the dirt instead of the crack walls, and the sealant may break away from the crack walls at some future time. How clean has possible ratings of clean, mostly clean, somewhat dirty, and dirty. Clean was assigned the highest rating, mostly clean received the second best rating, somewhat dirty received a low rating, and dirty received the lowest rating.

### Moisture

The presence of moisture on the surface is likely to interfere with the bond between the sealant and the crack walls as it will be difficult to keep the crack dry during sealing. Poor bonding results if moisture is present in the crack because the hot sealant will cause steam to develop. The steam can form a barrier or pocket between the sealant and crack walls.

The rating criteria for this attribute are dry, mostly dry, somewhat moist, and wet. The highest rating was assigned to dry. The ratings decrease as the surface moisture increases, thus wet received the lowest rating.

### Pavement temperature

The temperature of the sealant will almost immediately assume the temperature of the pavement surface to which it has been applied. Low pavement temperatures may cool the sealant too rapidly, causing the development of strain in the sealant between the cooled sealant and the warm sealant. The rapid cooling may also cause the sealant to become stiff before it is able to flow and fill the voids of the crack walls. This will result in poor bond development as the sealant will not come into good contact with the whole surface of the crack wall. High pavement temperatures may cause the sealant to remain in a very soft, or even liquid state, keeping the sealant from setting up. Pavement temperature has ranges of below 60°F, 60 to 80°F, 81 to 110°F, 111 to 130°F, and above 130°F. The 81 to 110°F range received the highest rating because problems associated with low and high temperatures are not present. The 60 to 80°F range received the second best rating; however, premature cooling of the sealant might be noticed. The third best rating was assigned to the 111 to 130°F range. Problems with the sealant setting up are possible within the 111 to 130°F range. The lowest ratings were assigned to below 60°F and above 130°F. Application should not take place if the pavement temperature is below 60°F due to pavement contraction and rapid cooling of the pavement. When the surface temperature is above 130°F, the sealant may not set up, and expansion of the pavement will be a problem.

#### *Primary type of cracks*

The six types of cracks being rated are: alligator, edge, block only, longitudinal, reflection, and transverse. The benefits of crack sealing vary depending upon the types of cracks present. It is effective for sealing surface cracks to prevent moisture penetration if there is no structural damage present. However, cracks resulting from structural failure of the pavement, such as alligator cracks, receive very little benefit from sealing. It is most effective for longitudinal, reflection, and transverse cracks, and these three received the highest rating. The second highest rating was assigned to block only. The third highest rating was assigned to edge crack. The lowest rating was assigned to alligator.

## Construction

The construction rating criteria is divided into five attributes. The attributes and their weights are: routing, 0.15; crack conditions, 0.25; sealant temperatures, 0.15; sealant application, 0.30; and finished sealant, 0.15. Sealant application received the highest weight

because of the large number of rating criteria related to it. Crack conditions received a high weight because of the number and the importance of the rating criteria within it.

### *Routing*

The purpose of routing is to make a crack wider, allowing a greater width of sealant to be placed in the crack. Increasing the width of the sealant reduces the strain which develops within the sealant during cold weather when the pavement shrinks, causing cracks to become wider. To be effective, the sealant must be able to withstand the strain which develops and remain bonded to the pavement on both sides of the crack as the crack widens.

Routing is a procedure used mainly in cold weather regions and may not be considered necessary in warm climates. The rating criteria related to routing is included in this rating method to accommodate for those regions where routing is required. In regions where routing is not required, the rating criteria is considered "not applicable". To avoid reducing the overall crack seal rating, a default rating value of 1.0 is used in the calculations for all rating criteria considered "not applicable."

The routing sub-attributes and their weights are: transverse cracks routed, 0.65; longitudinal cracks routed, 0.30; and routing accomplished in one pass, 0.05. The change in width of a crack due to thermal expansion and contraction is proportional to the length of pavement on each side of the crack. Therefore, the change in longitudinal crack width is limited by the width of the pavement surface and is usually much less than the change in width for transverse cracks. This explains the higher weight assigned to transverse cracks. Routing accomplished in one pass received a very low weight because it is much less important than the other two sub-attributes. Rating criteria for each of the three sub-attributes are yes, usually, sometimes, and no.

#### Transverse cracks routed

Routing of transverse cracks is important. It increases the sealant reservoir width, enabling the sealant to expand with less strain. The highest rating is assigned to yes, and the lowest is assigned to no.

#### Longitudinal cracks routed

Routing of longitudinal cracks is important to reduce strain in the sealant. The highest rating is assigned to yes, and the lowest to no.

## Routing accomplished in one pass

A much smoother and straighter crack edge results when routing is accomplished in one pass. Construction time and costs can also be reduced. The highest rating is assigned to yes, and the lowest to no.

### *Crack conditions*

The condition of a crack immediately prior to sealing is very important for the development of strong bonds between the sealant and the crack walls. Strong bonding is imperative to withstand the strain which develops in cold weather. Failure of the sealant to remain adhered to crack walls allows moisture to enter through the crack. The five sub-attributes and their weights are: cracks are clean, 0.35; cracks are dry, 0.30; hot air lance used, 0.10; asphalt around crack charred after heating, 0.15; crack still hot from air lance when sealant applied, 0.10. As reflected by the weights, cracks are clean and cracks are dry are the two most important sub-attributes. Rating criteria for the five sub-attributes are yes, usually, sometimes, and no.

## Cracks are clean

The cracks must be clean for adequate bonding to develop between the sealant and the crack walls. If the cracks are not clean, the sealant will bond to the debris in the crack instead of the crack wall and will not be effective in preventing moisture from entering through the crack. The highest rating was assigned to yes and the lowest to no.

## Cracks are dry

The cracks must be dry. Moisture in the cracks at the time of sealing will prevent the development of proper bonds between the sealant and crack walls. The highest rating was assigned to yes and the lowest to no.

## Hot air lance used

The hot air lance is a device which delivers hot air through a nozzle at a high velocity. It is very beneficial for cleaning debris from the cracks, and heats the pavement surrounding the crack. Heating the pavement helps the sealant bond to the pavement. The hot air lance also helps to remove some moisture, but is not effective if water is present on the pavement surface. The highest rating was assigned to yes and the lowest to no.

## Asphalt around crack charred after heating

The hot air lance should not be allowed to char the asphalt. This happens when the pavement becomes so hot that the asphalt burns and becomes damaged. Charring may prevent strong bonds from developing, and may also result in the charred asphalt breaking loose from the pavement. The highest rating was assigned to no and the lowest to yes.

## Crack still hot from air lance when sealant applied

The sealant is more likely to develop strong bonds with the walls of the crack if they are still hot when the sealant is applied. The highest rating was assigned to yes and the lowest to no.

### *Sealant temperatures*

Monitoring sealant temperatures is very important to receive maximum performance from the sealant. The manufacturer's recommended application temperatures should be followed. Maximum adhesive properties of the sealant are not present at low temperatures, especially for polymer modified sealants which require a certain temperature to be reached to assure the polymers are properly mixed. If the sealant reaches temperatures which are too high, damage can occur to the sealant and may cause it to become brittle.

When the sealant is applied at temperatures lower than the manufacturer recommends, inadequate bonding is likely to result. Low application temperatures may also hinder the ability of the sealant to fill the cracks due to increased viscosity of the sealant.

The three sub-attributes and their weights are: actual temperature of sealant at beginning of application, 0.35; actual temperature of sealant at end of application, 0.35; and number of times sealant was reheated, 0.30.

## Actual temperature of sealant at beginning of application

This is the temperature of the sealant when crack sealing begins. Four temperature ranges have been defined and are used to rate the actual temperature as it compares to the target temperature. The ranges are ± 2°F, ±5°F, ±10°F, and >±10°F. The range which best describes the actual temperature is selected. The highest rating was assigned to ±2°F. The second highest rating was assigned to ±5°F. The third highest rating was assigned to ±10°F. The lowest rating was assigned to >±10°F.

## Actual temperature of sealant at end of application

This is the temperature of the sealant at the end of crack sealing. The same temperature ranges and ratings were used for this sub-attribute as mentioned in the previous sub-attribute.

## Number of times sealant was reheated

This refers to the number of times the sealant was reheated after it had cooled below the recommended temperature. Four ranges have been defined to rate this sub-attribute. The ranges are 0-1, 2, 3, and >3. Damage may occur to the sealant if it is reheated too many times. The highest rating was assigned to 0-1. The second and third highest ratings were assigned to 2 and 3 respectively. These ratings were only slightly less than the highest rating. A significantly lower rating was assigned to >3.

## Sealant application

Information relative to the equipment and procedures used to apply the sealant is recorded under this attribute. The eight sub-attributes and their weights are: backflushed hose, 0.15; crack-filled flush, 0.10; sealant chamber heated, 0.15; hose between wand and sealant chamber heated, 0.15; material in chamber under constant agitation, 0.10; thermometer visible to the engineer, 0.10; blotting material used on cracks, 0.10; and distance between applicator wand and squeegee, 0.15. The four sub-attributes which received a weight of 0.15 are slightly more important than the others because they are related to items vital to the application temperature and placement of the sealant.

## Backflushed hose

Backflushing clears the hose of sealant material which may have cooled in the hose. Backflushing is necessary anytime the application of sealant has been delayed for a period greater than 15 minutes. This will reduce the possibility of applying the sealant at low temperatures which might hinder proper bonding. The highest rating was assigned to yes, and the lowest to no.

## Crack filler

The crack filler, or applicator wand, should be flushed for the same reasons mentioned above for the hose. The highest rating was assigned to yes, and the lowest to no.

## Sealant chamber heated

It is very important that the sealant chamber is able to maintain the sealant at the desired temperature. The sealant will not adhere properly if applied at a temperature below the manufacturer's recommendations. The highest rating was assigned to yes and the lowest to no.

## Hose between wand and sealant chamber heated

A hose which is heated is very beneficial. It reduces the problem of the sealant becoming cooled in the hose. The highest rating was assigned to yes and the lowest to no.

## Material in chamber under constant agitation

Agitation of the sealant material is necessary to keep it at a uniform temperature. Without agitation, the sealant near the heating source would be much warmer than the rest of the sealant. Thus, agitation helps to keep the sealant near the heating source from becoming too hot and keeps the sealant in the chamber at a uniform temperature. The highest rating was assigned to yes and the lowest to no.

## Thermometer visible to the engineer

It is important for the engineer to be able to monitor the temperature of the sealant. Damage may occur to the sealant if it is overheated. However, sealant which is below the manufacturer's suggested application temperature should not be applied until it has been heated to the proper temperature. The sealant chamber thermometer should be visible to the engineer. The highest rating was assigned to yes and the lowest to no.

## Blotting material used on cracks

Blotting materials are sometimes spread on sealant to soak up the excess sealant. They are not to be used in this study. The highest rating was assigned to no and the lowest to yes.

## Distance between applicator wand and squeegee (feet)

It is best for the squeegee to follow directly behind the applicator wand. The temperature of the sealant will reduce rapidly after being applied by the wand. Finishing the placement of the sealant as soon as possible after it has been applied is important because it should not be disturbed after it has cooled, for to do so can prevent proper bonding from

developing. Four ranges have been defined for rating purposes. The highest rating was assigned to <3 feet, the second highest rating was 3 to 5 feet, and the third highest 5 to 10 feet. The lowest rating was assigned to >10 feet.

### *Finished sealant*

The three sub-attributes of finished sealant and their weights are: average width of completed sealed crack (inches), 0.35; thickness of finished sealant, 0.35; and approximate average thickness of sealant above or below pavement surface (inches), 0.30.

## Average width of completed sealed crack (inches)

When the squeegee is passed over the applied sealant, the extra sealant is smeared to the pavement on both sides of the crack. The total width of the smear is measured. Widths greater than 2 inches indicate too much sealant was applied. Four ranges have been defined for rating purposes. The highest rating is assigned to <2 inches. The second highest rating is assigned to 2 to 3 inches, and the third highest to 3 to 4 inches. The lowest rating is assigned to >4 inches.

## Thickness of finished sealant

The thickness is based on how the sealant compares to the surrounding pavement. If the sealant is level with the surface, it receives the highest rating. This indicates enough sealant in the crack to adequately seal it. The second highest rating is given when the sealant is recessed. The lowest rating is given when the crack is overfilled. The sealant is subject to being pulled out of the crack by traffic if the crack is overfilled, a result of the wheels of the traffic constantly making contact with the sealant.

## Approximate average thickness of sealant above or below pavement surface (inches)

Seven ranges have been used to define the rating of the sealant thickness. The highest rating is assigned to two ranges, the 0.00 (level) range and the -0.10 (below surface) range. The second highest rating is for -0.20 inches. The third highest rating is for a sealant which is +0.10 inches. Two ranges have the next to lowest rating, the +0.20 and the >-0.20 ranges. The lowest rating belongs to the > +0.20 range.

## Curing

This main attribute contains information pertaining to the time allowed for the sealant to cure. The three attributes and their weights recorded under this main attribute are: time between completion of crack preparation and placement of sealant (minutes), 0.20; time between completion of crack sealing and opening to traffic at end where sealing began (hours), 0.40; and time between completion of crack sealing and opening to traffic at end where sealing ended (hours), 0.40.

### *Time between completion of crack preparation and placement of sealant (minutes)*

The hot air lance cleans debris from the crack and heats the pavement on both sides of the crack. Placing the sealant immediately after the hot air lance is used is important to take advantage of the sealant's ability to adhere more readily to a warm surface. A delay in the application of the sealant may allow the pavement to cool, thus losing the benefits of using the hot air lance. Five time ranges have been selected for rating criteria. They are $<1$ minute, 1 to 2 minutes, 2 to 5 minutes, 5 to 10 minutes, and $>10$ minutes. The highest rating was assigned to $<1$ minute. Ratings decrease as the time range increases, thus the lowest rating was assigned to $>10$ minutes.

### *Time between completion of crack sealant and opening to traffic at end where sealing began (hours)*

It is important to allow time for the sealant to cure before traffic is applied to the pavement. This attribute is concerned with the elapsed time between the completion of crack sealing and the opening to traffic at the location where crack sealing began. Traffic on the surface before adequate curing takes place may damage the bond between the sealant and the pavement and may also result in the sealant being removed from the crack if it sticks to the tires of the traffic. The following five time ranges have been selected as rating criteria; $<1$ hour, 1 to 2 hours, 2 to 4 hours, 4 to 8 hours, and $>8$ hours. The highest rating was assigned to $>8$ hours. Ratings decrease as curing time decreases, thus the lowest rating was assigned to $<1$ hour.

### *Time between completion of crack sealing and opening to traffic at end where sealing ended (hours)*

The same time ranges and ratings mentioned in the previous attribute apply to this attribute. This one differs as it is concerned with the elapsed time between the completion of crack sealing and the opening to traffic at the location where crack sealing ended.

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# Lessons Learned

## General

The following are observations recorded by H-101 staff, Project Engineers, and RCOC staff before, during, and after the application of the H-101 treatments. Many of these "Lessons Learned" are the result of extremely careful examination of the process of applying the H-101 maintenance treatments. However, these assertions are specific to the H-101 program and should receive more study before attempting to convert these observations into general practice.

1. Federal and State agencies can work together in a complex construction oriented research project and complete it in a relatively short period of time.

2. Some agencies will not accept certain treatments no matter how well they are applied. For example, an agency prejudiced against the use of a chip seal on Interstate type highway would, if there were any problems associated with the treatment, remove the treatment as unsafe, even though it was performing well.

3. The North Central region noted that the practice run of all applications at the demonstration site was very helpful for the contractor to check his equipment and procedures. It was also helpful for the Project Engineer to get acquainted with the operation, sequence of construction, and personnel (SHRP representatives, interested parties, and contractor personnel) involved. This response was echoed in the other regions.

4. The North Central region also noted that the weather, both temperature and humidity, had a significant impact on set times for the chip and slurry seal applications. Generally, conditions favorable for one were unfavorable for the other. Higher air and pavement surface temperatures would help the slurry seal lose water

and set, but would keep the chip seal too tacky to allow traffic. Cooler temperature seemed to quicken the set for the chip seal, but would delay evaporation and setting of the slurry seal. High humidity did not seem to slow setting of the chip seal, but definitely retarded the setting of the slurry seal.

5. It was the intent of the specifications, and of then Project Engineer, to complete each test site in it's entirety during one day. In most cases, this may not have been in the best interest of good research efforts. As noted above, ideal conditions for one application did not necessarily suit the requirements of another application. The North Central Project Engineer would have preferred to place the chip seal applications and then allow controlled, low speed traffic to work this application prior to brooming. The NC Project Engineer believed that this would have resulted in a much better setting of the chips and much less chip displacement would be experienced than that caused by an early brooming. A variation of this procedure was done in the other regions.

## Chip Seal Design

1. No uniform design is used for chip seals, and no best procedure has been identified by research. None was identified during the course of the research. However, factors that should be a part of this design have been identified. They are listed below.

2. Embedment of aggregate should be included in chip seal design to help determine the size of aggregate to be used.

3. Applying too much aggregate, or asphalt, is as bad or worse as not applying enough.

4. Upper, as well as lower, temperature limits should be included in the specifications.

5. The Southern region noted that the chip seals placed on "popcorn mixes", or open-graded surfaces, required much more emulsion than we originally estimated.

6. Slightly damp chips seemed to work better than dry or wet chips.

### *Chip Seal Distributor*

1. Asphalt distributors are not being calibrated for transverse application rate, and should be. However, the current ASTM procedure for asphalt distributor calibration is laborious and needs to be simplified.

2. Many pavements would have benefitted if we were able to apply a different asphalt application rate in the wheelpaths than between the wheelpaths. This is possible through the use of different size nozzles.

## *Chip Spreader*

1. Chip spreaders that kick the aggregate backward reduce aggregate rollover and reduces pickup of the aggregate on tires. The chip spreader in the North Central region was a variable width type machine. One half of the width had a plate that kicked the aggregate forward, while the other half had a plate that kicked the aggregate backward. The aggregate that was kicked backwards would fall vertically with little or no horizontal velocity and were therefore not susceptible to rolling. The half width that was kicked backwards generally looked better than the side that was kicked off of the forward facing plate and experienced less pickup on tires.

2. Chip spreaders are not being calibrated for longitudinal and transverse application rate, and should be. The chip spreader calibration procedure developed at the University of Reno is simple and effective for both longitudinal and transverse rates.

3. There are different philosophies on how soon after application of the emulsion to apply the chips. The two methods used were to apply the chips immediately after or as soon as the emulsion begins to grab a rock skipped across the surface. This second method was intended to reduce the occurrence of chips that hit the emulsion and then rolled over, leaving an emulsion coated surface that was easily picked up on the tires.

4. One problem that was noted in the Southern region only, was that after the dump truck connected with the chip spreader the dump truck bed is lifted higher and higher to pour the aggregate into the chip spreader. When the bed got to about 70° from the horizontal, there seemed to be enough downforce on the back end of the chip spreader to make it start bouncing. This would always seem to occur at about station 4+00 and would last for 50' to 75', leaving transverse, washboard type, corrugations. Although additional chips and hand brooming would help somewhat, occasionally a noticeable rumble would remain, even after curing, rolling, brooming, and the traffic was released. Also, soon after construction, a few motorists experienced windshield damage at three of the sites (that we are aware of) due to loose aggregate in the wheelpaths on the chip seal sections where rutting greater than 0.5" existed. If you broomed hard enough to get the excess chips out of the wheelpaths, then you would be loosening and removing the chips between the wheelpaths. Maintaining reduced speed traffic overnight on these sections may have helped to minimize this problem.

## *Chip Seal Rolling*

1. Many different rolling patterns, from one pass only, to five or seven passes, are used.

2. The amount of time after rolling, but before opening the surface to traffic seemed important in hot weather.

3. Requiring reduced speed for at least one hour, either by posting speed limits or through the use of pilot vehicles, seemed to reduce loss of chips.

## Slurry Seal

### *General*

1. A successful slurry depends on the skill and experience of the operator.

2. It may be possible to determine when a slurry can be opened to traffic by using a non-contact thermometer. When the temperature of the surface of the recently placed slurry approaches the temperature of the untreated lane, or of the lane that was treated much earlier, the lane may be ready to open. The surface temperatures of the treated and untreated lanes was one factor used in the North Central region to determine when to open the lane to traffic.

3. Roads with superelevation made it difficult to manage the spreader box to keep the slurry flowing well. On roads with no shoulders, the slurry box had to be kept up on the pavement. Otherwise, the slurry would flow out from under the box onto the shoulder.

4. Rutted areas take longer to cure.

### *Slurry Seal Specifications*

1. Upper, as well as lower, air and pavement temperature limits should be included in the specifications. When it is too cold, the slurry sets much too slowly. When it is too hot, the slurry tends to set too fast. To counteract this fast set, the operator will often add extra water which may affect the final product.

2. When soliciting bids for slurry seal work, it should be considered appropriate to require a certain minimum level of experience for the slurry machine operator; thereby avoiding many of the problems associated with placing and fine tuning a slurry mix.

3. Any oversized aggregate, or large clumps, get hung up under the strike-off bar. This leaves streaks in the fresh treatment. These streaks do seem to close up by themselves somewhat, but also usually fill up with the water coming out of the mix. This may leave a weak area. Perhaps requiring an on-site final screening is appropriate.

4. In the North Central region, hard water, pumped from an RV park may have contributed to set problems on a couple of sites. We also found out that cement purchased in Canada was different than cement from the U. S. The Canadian type 10 cement was purchased, based on local checks, and used on one site in Canada. A small amount was also used on another site. The slurry seal set up almost as soon as it hit the spreader box and the operator had to increase water to the pug mill, as well as to add water by spraying into the spreader box. It was only with a lot of hard labor that the slurry seal application was completed. Observation later seemed to indicate an acceptable application, but the site deserves extra concern due to this cement problem. Canadian type 2 is equivalent to U.S. type 1.

5. The time to opening of the slurry seal to traffic is highly dependant on the temperature of the pavement prior to placing the slurry.

## *Slurry Seal Mix design*

1. Slurry seal mix design is normally left to the contractor.

2. The operator should be allowed to change the amounts of slurry seal additives as the environmental conditions change.

3. The moisture content of the slurry seal aggregate is not important to the operator because the changes made to the mix are made by eye and feel.

## *Slurry Seal Calibration*

1. Slurry seal contractors typically calibrate their equipment once per year, but it is not required by most agencies. Slurry seal equipment calibration procedures are available, and the calibration is relatively simple. The calibration could be performed before every large job.

## *Slurry Seal Construction*

1. In the North Central region, the two hour set time for slurry seal was seldom observed. The time was generally longer. Also the slurry seal machine used in the North Central region had no means to monitor the amount of water added to the slurry seal mix. It would be helpful if we could determine the amount of water used in a mix and monitor success of an application with knowledge of this variable and other environmental factors.

## Crack Seal

### *General*

1. The hot-air lance seemed to be an effective tool in crack sealing.

2. The lance is easy to use and requires little training.

3. Surface cracks associated with paint striping and alligator cracking are not good candidates for crack sealing.

### *Crack Seal Construction*

1. If there is a moderate amount of debris left in the routed crack, two passes with the lance were required. One pass without heat was required to blow out the crack and a second pass with heat was used to prepare the crack for sealant. Another procedure that was used in the North Central region was to rout all of the cracks, broom the surface with the power broom, blow out the cracks with the air compressor only, and then use the Hot-Air Lance.

2. When sealing cracks routed to 1½ inches wide in the North Central region, a layer of single-ply toilet paper kept debris out of the cracks, helped in forming a skin over the sealant, and reduced time to opening the section to traffic without increasing tire pickup.

## Undersealing

1. Undersealing is not used as a preventative maintenance treatment.

2. The epoxy core test, which was developed in this project, is effective in defining the presence and thickness of voids under concrete pavements.

# 8

# Conclusions and Recommendations

Many factors have an effect upon the quality of the application of a pavement maintenance treatment. Items relative to environmental conditions, surface conditions, equipment used, application procedures, curing conditions, and traffic control have an impact on the expected performance of a treatment. Several important items are included within each of the classifications mentioned above. The overall quality of a treatment application is impaired when any important item, or combination of items, is out of specification.

Maintaining high quality throughout the treatment application is very important. The effectiveness of a maintenance treatment in extending pavement life is dependent upon the quality of the treatment application. High quality during the application phase yields a treatment which is expected to be very effective for extending the life of a pavement. Conversely, low application quality results in poor performance of the treatment.

Because there are many items which affect the quality, it is nearly impossible to quantify the quality of a treatment simply by observing the application of the treatment. This study developed an effective way to quantify the quality of treatment application. This requires one to consider the quality of each particular item which has an effect on the overall quality of the treatment. The influencing items must be identified, observed in the field, and individually evaluated according to their level of quality. Once a numerical value has been assigned to each item, an overall rating for the treatment can be obtained by combining the individual ratings.

Although the weights and ratings assigned to the rating trees may need to be adjusted, the rating procedure described in this report provides a practical and systematic way to quantify the quality of the application of pavement maintenance treatments. This type of procedure could be developed for other types of treatments in addition to chip seals, slurry seals, and crack sealing.

The following recommendations are made to improve the accuracy and dependability of the rating procedure.

1. The weights for the main attributes, attributes, and sub-attributes should be verified by experts on the three treatments. Some adjustments may need to be made to the weights, and it is suggested that a utility theory ranking procedure be investigated for possible use in determining the weights.

2. The ratings for the rating criteria should be reviewed by experts on the three treatments. Some adjustments may also need to be made for the ratings.

3. The weights and ratings probably need to be adjusted to suit local conditions. This may be very important, especially in relationship to environmental conditions. Adjustments will also be necessary if materials are changed such as using a viscosity graded asphalt in place of an emulsion for the chip seal binder.

4. The slurry seal sub-attribute "surface texture provided" should consider the skid resistance and the moisture resistance separately. Combining these two items for one rating does not allow an accurate evaluation. Rough and smooth describe skid resistance. Open and tight describe the ability to prevent moisture penetration. The data collection sheets were already being used when this was noticed. Thus, it was included in the rating trees, but should be changed.

# References


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# Appendix A

## Data Collection Sheets for Chip Seals, Slurry Seals, and Crack Sealing

Sheet 1 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## CHIP SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

1. *DATE WORK BEGAN (MONTH/DAY/YEAR) [__ __ / __ __ / __ __]

   *DATE WORK WAS COMPLETED (MONTH/DAY/YEAR) [__ __ / __ __ / __ __]

2. *TIME WORK WAS BEGUN (Hr/Min) [__ __/ __ __]

   *TIME OF DAY (AM = 1, PM = 2) [__]

   *TIME WORK WAS COMPLETED (Hr/Min) [__ __/ __ __]

   *TIME OF DAY (AM = 1, PM = 2) [__]

3. *LENGTH OF TEST SECTION SEALED (Feet) [__ __ __ __]

   *WIDTH OF TEST SECTION SEALED (Feet) [__ __.__]

4. *TYPE OF SEAL COAT [3]
   AGGREGATE SEAL.....3

5. *TYPE/GRADE OF BITUMINOUS MATERIAL IN SEAL COAT
   (SEE TABLE A.16 FOR TYPE CODE) [__ __]
   DESCRIPTION OF "OTHER CEMENT" [_____]

   MANUFACTURER NAME [_____]

   MANUFACTURER MATERIAL NAMES [_____]

6. *WAS APPLICATION RATE OF BITUMINOUS MATERIAL ADJUSTED AT JOBSITE TO CORRECT FOR SURFACE CONDITION (YES = 1, NO = 2) [__]

7. *TARGET APPLICATION RATE FOR BITUMINOUS MATERIAL (Gallons/Sq. Yd) [.__ __ __]

8. *ACTUAL APPLICATION RATE FOR BITUMINOUS MATERIAL MEASURED FROM DISTRIBUTOR READINGS (Gallons/Sq. Yd) [.__ __ __]

9. *ACTUAL APPLICATION RATE FOR BITUMINOUS MATERIAL MEASURED FROM DISTRIBUTOR TANK MEASUREMENTS (Gallons/Sq. Yd) [.__ __ __]

10. *TARGET APPLICATION TEMPERATURE OF BITUMINOUS MATERIAL (°F) [__ __ __]

11. *ACTUAL APPLICATION TEMPERATURE OF BITUMINOUS MATERIAL (°F) [__ __ __]

Sheet 2 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## CHIP SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

12. *TYPE OF AGGREGATE USED IN SEAL COAT
(SEE TABLE A.9 FOR TYPE CODE) [__ __]

DESCRIPTION OF "OTHER AGGREGATE" [_____]

AGGREGATE SOURCE [_____]

13. *TARGET APPLICATION RATE FOR AGGREGATE (Pounds/Sq. Yard) [__ __.__]

14. *ACTUAL APPLICATION RATE FOR AGGREGATE IN WHEEL PATHS
(Pounds/Sq. Yard) [__ __.__]

15. *ACTUAL APPLICATION RATE FOR AGGREGATE BETWEEN WHEEL PATHS
(Pounds/Sq. Yard) [__ __.__]

16. *INITIAL EXISTING PAVEMENT SURFACE PREPARATION (SWEEPING REQUIRED) [__]

| | |
|---|---|
| NONE.....1 | COLD MILL.....3 |
| SWEEP CLEAN ONLY.....2 | SHOT BLAST.....4 |
| OTHER (SPECIFY) _____ | 5 |

17. *PAVEMENT CONDITIONS AT TIME SEAL COAT APPLIED
PAVEMENT TEMPERATURE (°F) (60 °F Required) [__ __ __]

CONDITION OF SURFACE BEFORE SEALING [__]

| | |
|---|---|
| CLEAN .....1 | MOSTLY CLEAN.....2 |
| SOMEWHAT DIRTY....3 | DIRTY.....4 |

SURFACE MOISTURE CONDITION [__]

| | |
|---|---|
| DRY ..... 1 | MOSTLY DRY.....2 |
| SOMEWHAT MOIST.....3 | WET.....4 |

18. *AMBIENT CONDITIONS AT TIME SEAL COAT APPLIED
AIR TEMPERATURE (°F) (60 °F Required) LOW [__ __ __]
HIGH [__ __ __]

RELATIVE HUMIDITY (Percent) [__ __ __]

19. *SURFACE CONDITION [__]

| | |
|---|---|
| BADLY OXIDIZED .....1 | NORMAL .....3 |
| SLIGHTLY OXIDIZED.....2 | SLIGHTLY FLUSHED.....4 |
| FLUSHED.....5 | FLUSHED ONLY IN WHEEL PATHS..6 |
| OTHER (SPECIFY) _____ | 7 |

| | | |
|---|---|---|
| Sheet 3 | *STATE ASSIGNED ID | [__ __ __ __] |
| SPS-3 DATA | *STATE CODE | [__ __] |
| LTPP PROGRAM | *SHRP SECTION ID | [__ __ __ __] |

CHIP SEAL APPLICATION DATA FOR PAVEMENT WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE THE LANE CONTAINING THE SPS-3 TEST SECTION

20. *AVERAGE CRACK SEVERITY LEVEL (SEE DISTRESS IDENTIFICATION MANUAL)
LOW = 1, MODERATE = 2, HIGH = 3 [__]

21. *PRIMARY TYPE OF CRACKS (SEE TABLE A.22 FOR TYPE CODES) [__ __]
SEE DISTRESS IDENTIFICATION MANUAL FOR DESCRIPTION

22. *ESTIMATED PERCENT OF CRACKS SEALED [__ __ __]

23. *AGGREGATE CONDITION PRIOR TO USE (CLEAN OR ONLY SLIGHTLY DIRTY REQUIRED)
CLEAN = 1 ONLY SLIGHTLY DIRTY = 2 SOMEWHAT DIRTY = 3 DIRTY = 4 [__]

VERY DRY.....1 DRY..... 2 ONLY SLIGHTLY DAMP..3
SOMEWHAT DAMP..... 4 SLIGHTLY WET.. 5 WET..... 6 [__]

24. *AGGREGATE MOISTURE CONTENT (PERCENT BY WEIGHT) [__ __.__]

25. *ESTIMATED TIME BETWEEN APPLICATION OF BITUMINOUS MATERIAL AND SPREADING OF AGGREGATE MATERIAL (SECONDS) [__ __ __]

26. *ESTIMATED TIME BETWEEN APPLICATION OF AGGREGATE MATERIAL AND INITIAL ROLLING (SECONDS) [__ __ __]

27. *NUMBER OF COVERAGES PER ROLLER (THREE REQUIRED) [__]

28. *TRAFFIC KEPT OFF OF SURFACE UNTIL ROLLING COMPLETED
(YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4) [__]

29. *ESTIMATED TIME REQUIRED TO COMPLETE ROLLING AFTER AGGREGATE IS SPREAD (Minutes) [__ __.__]

30. *ESTIMATED TIME BETWEEN FINAL ROLLING AND BROOMING SECTION (HOURS) [__ __.__]

31. *ESTIMATED TIME BETWEEN FINAL ROLLING AND OPENING SECTION TO REDUCED SPEED TRAFFIC (HOURS) [__ __.__]

32. *MAXIMUM REDUCED SPEED ALLOWED (MPH) [__ __]

33. *ESTIMATED TIME BETWEEN FINAL ROLLING AND OPENING SECTION TO FULL SPEED TRAFFIC (HOURS) [__ __.__]

34. *METHOD USED TO CONTROL TRAFFIC SPEED (PILOT VEHICLES = 1, FLAGMEN = 2, SIGNS = 3, NONE = 4) [__]

Sheet 4 *STATE ASSIGNED ID [__ __ __ __ ]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## EQUIPMENT USED IN CHIP SEAL APPLICATION

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

35. *ROLLER DATA

| ROLLER BRAND AND NUMBER | ROLLER DESCRIPTION | GROSS WT. (TONS) | TIRE PRES (PSI) | WIDTH (INCHES) | SPEED (MPH) |
|---|---|---|---|---|---|
| _____ | Pneumatic-tired | __ __.__ | __ __ __.__ | __ __.__ | __.__ |
| _____ | Pneumatic-tired | __ __.__ | __ __ __.__ | __ __.__ | __.__ |
| _____ | Pneumatic-tired | __ __.__ | __ __ __.__ | __ __.__ | __.__ |
| _____ | Pneumatic-tired | __ __.__ | __ __ __.__ | __ __.__ | __.__ |

36. *ROLLING INFORMATION (YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)

ROLLER SPEED EXCEEDS 5 MPH [__]

FINAL ROLLER COVERAGES IN DIRECTION OF TRAFFIC [__]

ROLLERS OPERATE IN A LONGITUDINAL FORWARD DIRECTION [__]

37. *DISTRIBUTOR

BRAND _____

MODEL _____

YEAR [__ __ __ __]

NOZZLE ANGLE (Degrees) [__ __]

SPRAY BAR HEIGHT (Inches) [__ __.__]

NOZZLE SPACING (Inches) [__ __.__]

NOZZLE BRAND _____

MODEL _____

38. *DISTRIBUTOR DETAILS (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4)

CLEANED BEFORE USE [__]

EQUIPPED WITH A BITUMETER THAT REGISTERS IN FT/MIN OR GAL/SY [__]

BITUMETER VISIBLE TO OPERATOR [__]

BITUMETER USED BY OPERATOR [__]

EQUIPPED WITH A TACHOMETER ON THE PUMP [__]

TACHOMETER VISIBLE TO THE OPERATOR [__]

TACHOMETER USED BY OPERATOR [__]

EQUIPPED WITH HEATERS THAT CAN BE USED TO BRING THE EMULSIFIED ASPHALT MATERIAL TO SPRAY APPLICATION TEMPERATURE [__]

THERMOMETER VISIBLE TO OPERATOR [__]

THERMOMETER WELL FREE OF CONTACT WITH THE HEATING TUBE? [__]

EQUIPPED WITH A FULL CIRCULATORY SYSTEM INCLUDING THE SPRAY BAR [__]

Sheet 5 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## EQUIPMENT USED IN CHIP SEAL APPLICATION (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

39. *DOUBLE OR TRIPLE LAP (DOUBLE = 1, TRIPLE = 2) [___]

40. *APPLICATION OF ASPHALT (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4, NA = 5)
    - WAS UNIFORM SPRAY APPLIED [___]
    - WAS ATOMIZATION NOTICED [___]
    - WERE ANY LOCATIONS MISSED OR DEFICIENT IN ASPHALT [___]
    - WAS A HANDSPRAYER USED TO TOUCH UP MISSED SPOTS [___]
    - WAS BUILDING PAPER USED AT THE BEGINNING OF THE TREATMENT [___]
    - WAS BUILDING PAPER USED AT THE END OF THE TREATMENT [___]
    - WAS STREAKING OF THE ASPHALT NOTICED [___]
    - WERE END NOZZLES USED TO ALLOW FOR AN OVERLAP OF EMULSIFIED ASPHALT BINDER TO THE ADJACENT LANE [___]

41. *AGGREGATE SPREADER
    - BRAND _____
    - MODEL _____

42. *IS A SELF-PROPELLED MECHANICAL SPREADER USED ? (YES = 1, NO = 2) [___]

43. *SPREADING OF AGGREGATE (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4, NA = 5)
    - IS AGGREGATE SPREAD UNIFORMLY [___]
    - IS STREAKING OF THE AGGREGATE NOTICED [___]

44. *IS A MOTORIZED POWER BROOM USED TO REMOVE LOOSE MATERIAL FROM THE SURFACE AFTER ROLLING IS COMPLETE? (YES = 1, NO = 2) [___]

45. *NUMBER OF PASSES WITH BROOM [__ __]

46. *ESTIMATED PERCENT OF LOOSE MATERIAL REMOVED DURING BROOMING [___]
    - NONE (<1%).....1
    - VERY LITTLE (1 - 3%).....2
    - SOME (3 - 5%).....3
    - SUBSTANTIAL (>5%).....4

47. *ESTIMATED PERCENT OF LOOSE MATERIAL REMAINING AFTER BROOMING [___]
    - NONE (<1%).....1
    - VERY LITTLE (1 - 3%).....2
    - SOME (3 - 5%).....3
    - SUBSTANTIAL (>5%).....4

Sheet 6 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## SLURRY SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

1. *DATE WORK BEGAN (MONTH/DAY/YEAR) [__ __/__ __/__ __]

   *DATE WORK WAS COMPLETED (MONTH/DAY/YEAR) [__ __/__ __/__ __]

2. *TIME WORK WAS BEGUN (Hr/Min) [__ __/__ __]

   TIME OF DAY (AM = 1, PM = 2) [__]

   *TIME WORK WAS COMPLETED (Hr/Min) [__ __/__ __]

   TIME OF DAY (AM = 1, PM = 2) [__]

3. *LENGTH OF TEST SECTION SEALED (Feet) [__ __ __ __]

   *WIDTH OF TEST SECTION SEALED (Feet) [__ __.__]

4. *TYPE OF SEAL COAT [2]
   SLURRY SEAL.....2

5. *TYPE/GRADE OF BITUMINOUS MATERIAL IN SLURRY SEAL
   (SEE TABLE A.16 FOR TYPE CODE) [__ __]
   DESCRIPTION OF "OTHER CEMENT" [_____]

   MANUFACTURER NAME [_____]

   MANUFACTURER MATERIAL NAMES [_____]

6. *TYPE OF AGGREGATE USED IN SLURRY SEAL
   (SEE TABLE A.9 FOR TYPE CODE) [__ __]
   DESCRIPTION OF "OTHER AGGREGATE" [_____]

   AGGREGATE SOURCE [_____]

7. *TYPE OF MINERAL FILLER USED IN SLURRY SEAL
   (SEE TABLE A.15 FOR TYPE CODE) [__ __]
   DESCRIPTION OF "OTHER" [_____]

   MINERAL FILLER SOURCE [_____]

| | | |
|---|---|---|
| Sheet 7 | *STATE ASSIGNED ID | [__ __ __ __] |
| SPS-3 DATA | *STATE CODE | [__ __] |
| LTPP PROGRAM | *SHRP SECTION ID | [__ __ __ __] |

SLURRY SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONT.)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

8. *REVOLUTION COUNT OF SLURRY SEAL MACHINE BEFORE APPLICATION [__ __ __ __]

9. *REVOLUTION COUNT OF SLURRY SEAL MACHINE AFTER APPLICATION [__ __ __ __]

10. *TARGET APPLICATION RATE FOR BITUMINOUS MATERIAL (Gallons/Sq. Yd) [.__ __ __]

11. *ACTUAL APPLICATION RATE FOR BITUMINOUS MATERIAL MEASURED FROM DISTRIBUTOR READINGS (Gallons/Sq. Yd) [.__ __ __]

12. *WAS APPLICATION RATE OF BITUMINOUS MATERIAL ADJUSTED AT JOBSITE TO CORRECT FOR SURFACE CONDITION (YES = 1, NO = 2) [__]

13. *TARGET APPLICATION RATE FOR AGGREGATE (Pounds/Sq. Yard) [__ __.__]

14. *ACTUAL APPLICATION RATE FOR AGGREGATE FROM DISTRIBUTOR READINGS (Pounds/Sq. Yard) [__ __.__]

15. *GATE OPENING (INCHES) [__ __.__]

16. *TARGET APPLICATION RATE FOR MINERAL FILLER (Pounds/Sq. Yard) [__.__ __]

17. *ACTUAL APPLICATION RATE FOR MINERAL FILLER FROM DISTRIBUTOR READINGS (Pounds/Sq. Yard) [__.__ __]

18. *MINERAL FILLER SETTING [__ __.__ __]

19. *TARGET APPLICATION RATE FOR SLURRY MIXTURE (Pounds/Sq. Yard) [__ __.__]

20. *ACTUAL APPLICATION RATE FOR SLURRY MIXTURE FROM DISTRIBUTOR READINGS (Pounds/Sq. Yard) [__ __.__]

21. *AMOUNT OF WATER ADDED (Gallons per Gallon of Emulsion) [__.__ __]

Sheet 8 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## SLURRY SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONT.)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

22. *ACTUAL TEMPERATURE OF BITUMINOUS MATERIAL PRIOR TO APPLICATION (°F) [___ ___ ___]

23. *ACTUAL APPLICATION TEMPERATURE OF SLURRY MATERIAL (°F) [__ __ __]

24. *INITIAL EXISTING PAVEMENT SURFACE PREPARATION (SWEEPING REQUIRED) [___]

| | |
|---|---|
| NONE.....1 | COLD MILL.....3 |
| SWEEP CLEAN ONLY.....2 | SHOT BLAST.....4 |
| OTHER (SPECIFY) _____ | 5 |

25. *PAVEMENT CONDITIONS AT TIME SEAL COAT APPLIED

PAVEMENT TEMPERATURE (°F) (60 °F Required) [__ __ __]

CONDITION OF SURFACE BEFORE SEALING [___]

| | |
|---|---|
| CLEAN .....1 | MOSTLY CLEAN.....2 |
| SOMEWHAT DIRTY....3 | DIRTY.....4 |

SURFACE MOISTURE CONDITION [___]

| | |
|---|---|
| DRY ..... 1 | MOSTLY DRY.....2 |
| SOMEWHAT MOIST.....3 | WET.....4 |

26. *AMBIENT CONDITIONS AT TIME SEAL COAT APPLIED

AIR TEMPERATURE (°F) (60 °F Required) LOW [__ __ __]
HIGH [__ __ __]

RELATIVE HUMIDITY (Percent) [__ __ __]

Sheet 9 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

SLURRY SEAL APPLICATION DATA FOR PAVEMENT WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE THE LANE CONTAINING THE SPS-3 TEST SECTION

27. *SURFACE CONDITION [__]

| | |
|---|---|
| BADLY OXIDIZED .....1 | NORMAL .....3 |
| SLIGHTLY OXIDIZED.....2 | SLIGHTLY FLUSHED.....4 |
| FLUSHED.....5 | FLUSHED ONLY IN WHEEL PATHS..6 |
| OTHER (SPECIFY) _____ | 7 |

28. *AVERAGE CRACK SEVERITY LEVEL (SEE DISTRESS IDENTIFICATION MANUAL)
LOW = 1, MODERATE = 2, HIGH = 3 [__]

29. *PRIMARY TYPE OF CRACKS (SEE TABLE A.22 FOR TYPE CODES) [__ __]
SEE DISTRESS IDENTIFICATION MANUAL FOR DESCRIPTION

30. *ESTIMATED PERCENT OF CRACKS SEALED [__ __ __]

31. *AGGREGATE CONDITION PRIOR TO USE (CLEAN OR ONLY SLIGHTLY DIRTY REQUIRED)
CLEAN = 1 ONLY SLIGHTLY DIRTY = 2 SOMEWHAT DIRTY = 3 DIRTY = 4 [__]

| | | | |
|---|---|---|---|
| VERY DRY.....1 | DRY..... 2 | ONLY SLIGHTLY DAMP..3 | |
| SOMEWHAT DAMP..... 4 | SLIGHTLY WET.. 5 | WET..... 6 | [__] |

32. *AGGREGATE MOISTURE CONTENT (PERCENT BY WEIGHT) [__ __.__]

33. *ESTIMATED TIME BETWEEN APPLICATION AND OPENING SECTION
TO REDUCED SPEED TRAFFIC (HOURS) [__ __.__]

34. *MAXIMUM REDUCED SPEED ALLOWED (MPH) [__ __]

35. *ESTIMATED TIME BETWEEN APPLICATION AND OPENING SECTION
TO FULL SPEED TRAFFIC (HOURS) [__ __.__]

36. *METHOD USED TO CONTROL TRAFFIC SPEED (PILOT VEHICLES = 1,
FLAGMEN = 2, SIGNS = 3, NONE = 4) [__]

Sheet 10 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## EQUIPMENT USED IN SLURRY SEAL APPLICATION

37. *SLURRY MIXING MACHINE
BRAND _____
MODEL _____
YEAR [__ __ __ __]

38. *SLURRY MIXING MACHINE DETAILS (YES = 1, USUALLY = 2 SOMETIMES = 3, NO = 4)

| | |
|---|---|
| CONTINUOUS FLOW MIXING | [___] |
| ACCURATELY APPORTIONED MIX COMPONENTS | [___] |
| DISCHARGED THOROUGHLY MIXED PRODUCT CONTINUOUSLY | [___] |
| AGGREGATE PREWET IMMEDIATELY PRIOR TO MIXING WITH EMULSION | [___] |
| INGREDIENTS THOROUGHLY BLENDED IN THE MIXING CHAMBER | [___] |
| METERING DEVICE INTRODUCES PREDETERMINED PROPORTION OF MINERAL FILLER INTO THE MIXER | [___] |
| MINERAL FILLER FED AT SAME TIME AND LOCATION AS THE AGGREGATE | [___] |
| FINES FEEDER PROVIDED FOR MINERAL FILLER | [___] |
| FOG SPRAY (WATER) USED PRIOR TO SLURRY SEAL | [___] |
| EQUIPPED WITH A MECHANICAL TYPE SQUEEGEE DISTRIBUTOR | [___] |
| FLEXIBLE REAR STRIKEOFF USED | [___] |
| FLEXIBLE REAR STRIKEOFF KEPT IN CONTACT WITH PAVEMENT SURFACE | [___] |
| WORKING STEERING DEVICE ON SPREADER BOX | [___] |
| SPREADER BOX KEPT CLEAN AND FREE OF BUILDUP | [___] |
| WAS SPREADER BOX OVERLOADED | [___] |
| WAS SPREADER BOX EVENLY FILLED AT ALL TIMES | [___] |
| WAS ANY LUMPING, BALLING, OR UNMIXED AGGREGATE NOTICED | [___] |
| WAS SEGREGATION OF THE EMULSION AND AGGREGATE FINES FROM THE COARSE AGGREGATE NOTICED | [___] |
| SLURRY REMAINED WELL MIXED IN SPREADER BOX | [___] |
| WAS BREAKING OF EMULSION OBSERVED IN THE SPREADER BOX | [___] |
| BUILD-UP OF MATERIAL ALONG LONGITUDINAL AND TRANSVERSE JOINT | [___] |

39. *SETTING OF SPREADER BOX WIDTH (Inches) [__ __ __.]

40. *TYPE OF DRAG USED (NONE = 1, BURLAP = 2, OTHER = 3) [___]
OTHER (SPECIFY) _____

41. *SURFACE TEXTURE PROVIDED [___]

| | |
|---|---|
| ROUGH AND OPEN.....1 | SOMEWHAT ROUGH AND OPEN .....2 |
| SOMEWHAT SMOOTH AND TIGHT....3 | SMOOTH AND TIGHT.....4 |

Sheet 11 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## CRACK SEAL DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

1. *DATE WORK BEGAN (MONTH/DAY/YEAR) [__ __/__ __/__ __]

   *DATE WORK WAS COMPLETED (MONTH/DAY/YEAR) [__ __/__ __/__ __]

2. *TIME WORK WAS BEGUN (Hr/Min) [__ __/__ __]

   TIME OF DAY (AM = 1, PM = 2) [__]

   *TIME WORK WAS COMPLETED (Hr/Min) [__ __/__ __]

   TIME OF DAY (AM = 1, PM = 2) [__]

3. *LENGTH OF TEST SECTION (Feet) [__ __ __ __]

   *WIDTH OF TEST SECTION (Feet) [__ __.__]

4. *INITIAL EXISTING PAVEMENT SURFACE PREPARATION (SWEEPING REQUIRED) [__]

   NONE.....1 COLD MILL.....3
   SWEEP CLEAN ONLY.....2 SHOT BLAST.....4
   OTHER (SPECIFY) _____5

5. *AMBIENT CONDITIONS AT TIME SEAL COAT APPLIED

   AIR TEMPERATURE (°F) (60 °F Required) LOW [__ __ __]
   HIGH [__ __ __]

   RELATIVE HUMIDITY (Percent) [__ __ __]

6. *PAVEMENT CONDITIONS AT TIME CRACK SEAL APPLIED

   PAVEMENT TEMPERATURE (°F) (60 °F Required) [__ __ __]

   CONDITION OF SURFACE BEFORE SEALING [__]
   CLEAN .....1 MOSTLY CLEAN.....2
   SOMEWHAT DIRTY....3 DIRTY.....4

   SURFACE MOISTURE CONDITION [__]
   DRY ..... 1 MOSTLY DRY.....2
   SOMEWHAT DAMP.....3 WET.....4

Sheet 12 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

## CRACK SEAL DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

7. *SURFACE CONDITION [__]
   BADLY OXIDIZED .....1 NORMAL .....3
   SLIGHTLY OXIDIZED.....2 SLIGHTLY FLUSHED.....4
   FLUSHED.....5 FLUSHED ONLY IN WHEEL PATHS..6
   OTHER (SPECIFY) _____

8. *AVERAGE CRACK SEVERITY LEVEL (SEE DISTRESS IDENTIFICATION MANUAL)
   LOW = 1, MODERATE = 2, HIGH = 3 [__]

9. *PRIMARY TYPE OF CRACKS (SEE TABLE A.22 FOR TYPE CODES) [__ __]
   SEE DISTRESS IDENTIFICATION MANUAL FOR DESCRIPTION

10. *ESTIMATED PERCENT OF CRACKS SEALED [__ __ __]

11. *APPROXIMATE TOTAL LENGTH OF CRACKS SEALED (FEET) [__ __ __ __]

12. *TYPE OF ASTM D3405 MATERIAL USED TO SEAL CRACKS
    MANUFACTURER NAME_____
    MANUFACTURER SEALANT NAME_____

13. *INFORMATION ON ROUTING (YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)
    TRANSVERSE CROACKS ROUTED [__]
    DIAGONAL CRACKS ROUTED [__]
    LONGITUDINAL CRACKS ROUTED [__]
    ROUTING ACCOMPLISHED IN ONE PASS [__]

14. *DIMENSIONS OF CRACK OR ROUTED RESERVOIR (AFTER PREPARATION)
    WIDTH (INCHES)
    MINIMUM.....[__.__ __] MAXIMUM.....[__.__ __]
    MEAN.....[__.__ __]

    DEPTH (INCHES)
    MINIMUM.....[__.__ __] MAXIMUM.....[__.__ __]
    MEAN.....[__.__ __]

    TOTAL LENGTH OF CRACKS PREPARED [__ __ __ __]

| | | |
|---|---|---|
| Sheet 13 | *STATE ASSIGNED ID | [__ __ __ __] |
| SPS-3 DATA | *STATE CODE | [__ __] |
| LTPP PROGRAM | *SHRP SECTION ID | [__ __ __ __] |

## CRACK SEAL DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

15. *CONDITION OF CRACK JUST PRIOR TO SEALING
(YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)

CLEAN [___]
DRY [___]

WAS HOT-AIR LANCE USED [___]
WAS ASPHALT AROUND CRACK CHARRED AFTER HEATING [___]
WAS CRACK STILL HOT FROM THE HOT-AIR LANCE WHEN SEALANT WAS PLACED [___]

16. *MAKE AND MODEL OF SEALANT HEATING KETTLE AND APPLICATOR
MODEL NAME _____
MODEL NUMBER _____

17. *MAXIMUM ALLOWABLE TEMPERATURE OF THE SEALANT (°F) [___]

18. *ACTUAL TEMPERATURE OF THE SEALANT AT THE BEGINNING OF APPLICATION (°F) [___]

19. *ACTUAL TEMPERATURE OF THE SEALANT AT THE END OF APPLICATION (°F) [___]

20. *WAS ANY SEALANT REHEATED (YES =1, NO = 2) [___]

21. *HOW MANY TIMES WAS SEALANT REHEATED [___]

| | | |
|---|---|---|
| Sheet 14 | *STATE ASSIGNED ID | [__ __ __ __ ] |
| SPS-3 DATA | *STATE CODE | [__ __] |
| LTPP PROGRAM | *SHRP SECTION ID | [__ __ __ __] |

CRACK SEAL DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

22. *SEALANT APPLICATION (YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)

| | |
|---|---|
| BACKFLUSHED HOSE | [___] |
| CRACK FILLER FLUSHED | [___] |
| SEALANT CHAMBER HEATED | [___] |
| HOSE BETWEEN WAND AND SEALANT CHAMBER HEATED | [___] |
| MATERIAL IN CHAMBER UNDER CONSTANT AGITATION | [___] |
| THERMOMETER VISIBLE TO THE ENGINEER | [___] |
| BLOTTING MATERIAL USED ON THE CRACKS | [___] |
| DISTANCE BETWEEN APPLICATOR WAND AND SQUEEGEE (FEET) | [___ ___] |
| AVERAGE WIDTH OF COMPLETED SEALED CRACK | [___.___] |

23. *THICKNESS OF FINISHED SEALANT [___]

CRACK OVERFILLED.....1 RECESSED .....2
LEVEL WITH SURFACE.....3

APPROXIMATE AVERAGE THICKNESS OF SEALANT ABOVE OR BELOW PAVEMENT SURFACE (INCHES) [.___ ___]

24. *LENGTH OF TIME BETWEEN

COMPLETION OF CRACK PREPARATION AND SEALANT PLACEMENT (MINUTES) [___ ___.___]

COMPLETION OF CRACK SEALANT AND OPENING TO TRAFFIC AT END WHERE SEALING BEGAN (HOURS) [___ ___.___ ___]

COMPLETION OF CRACK SEALANT AND OPENING TO TRAFFIC AT END WHERE SEALING ENDED (HOURS) [___ ___.___ ___]

# Appendix B

## Rating Trees for Chip Seals, Slurry Seals, and Crack Sealing

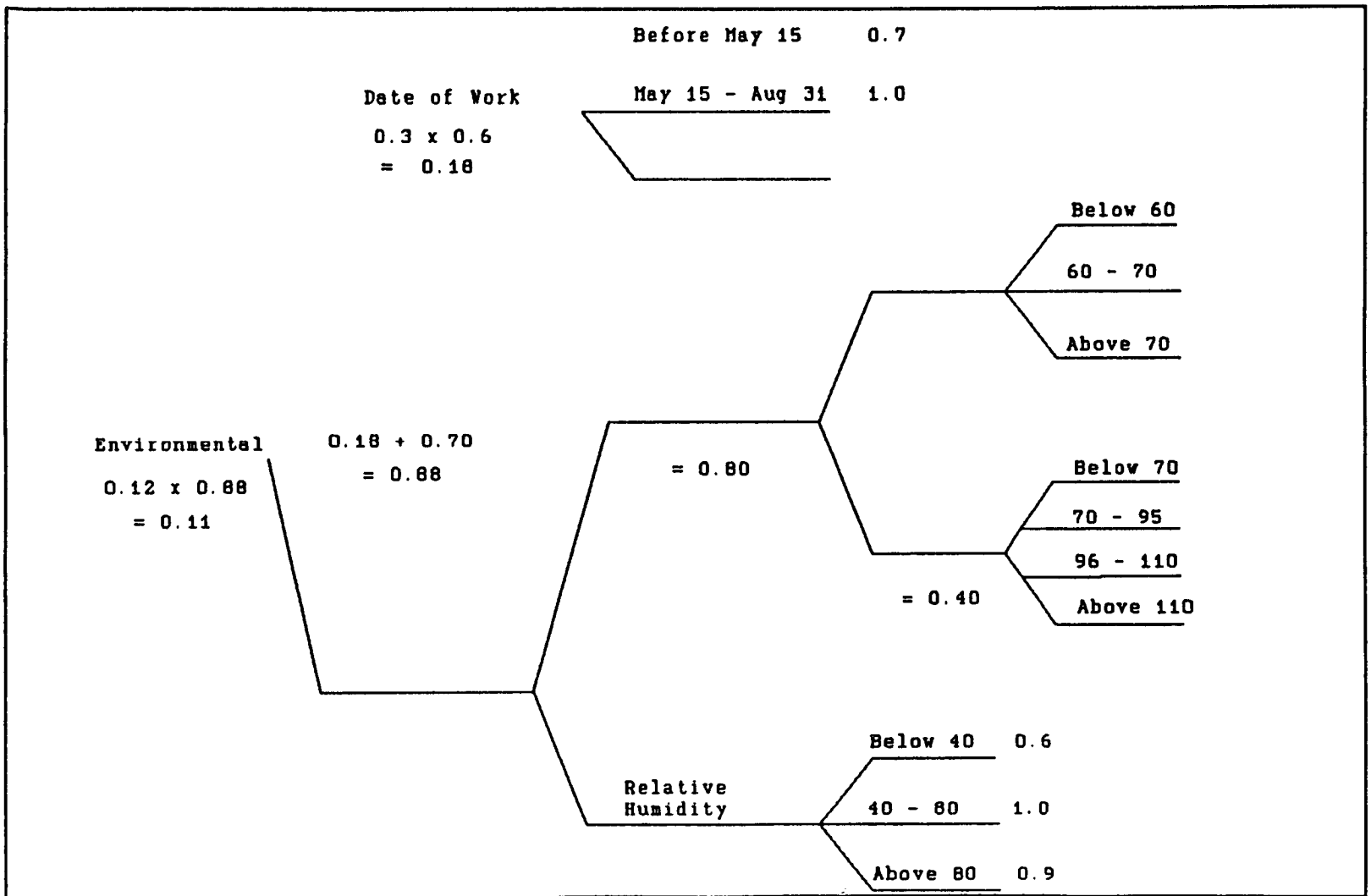


Figure 1. Example - Chip Seal Environmental Main Attribute Branch

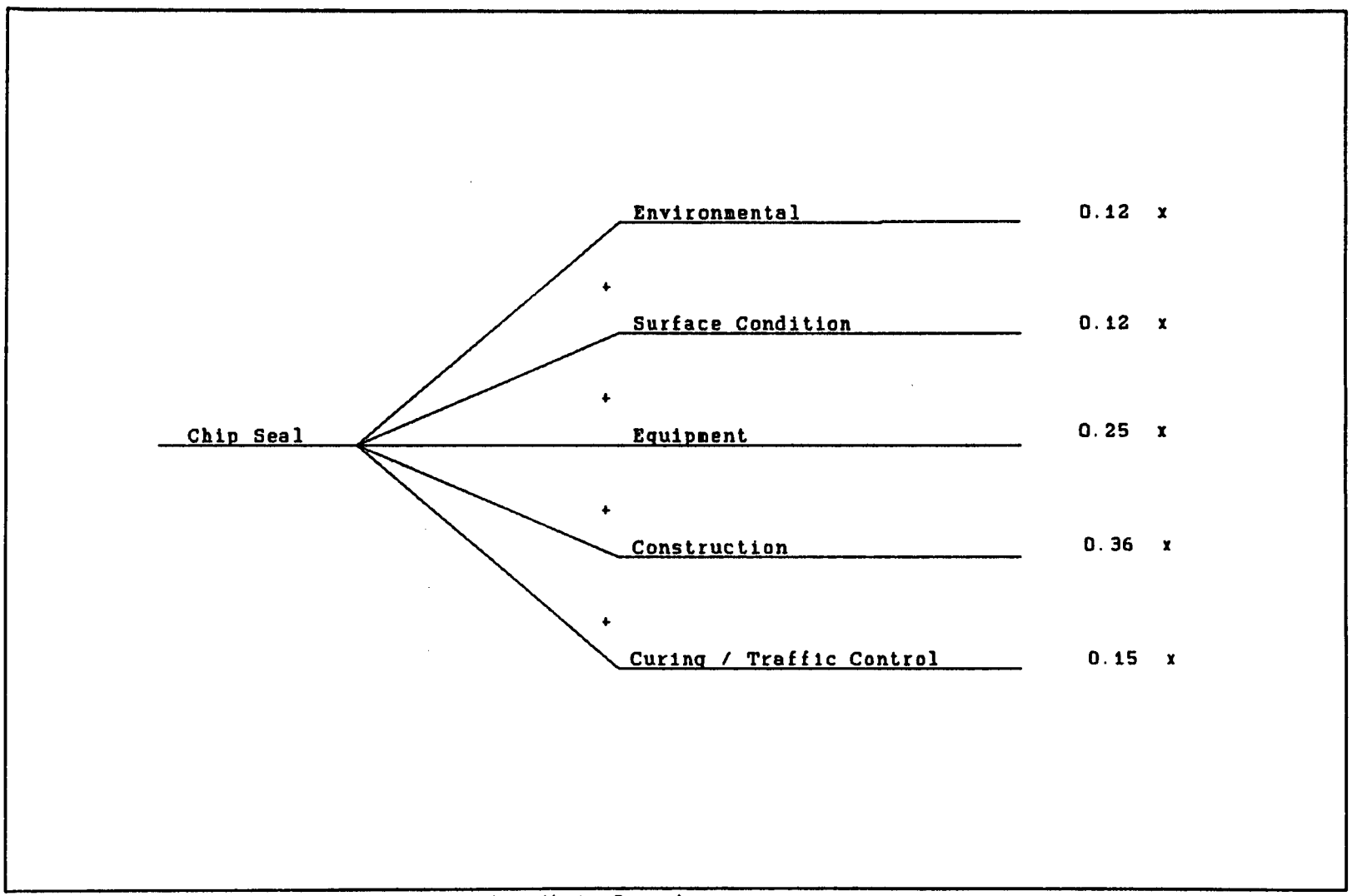


Figure 2. Chip Seal Rating Tree Main Attribute Branches

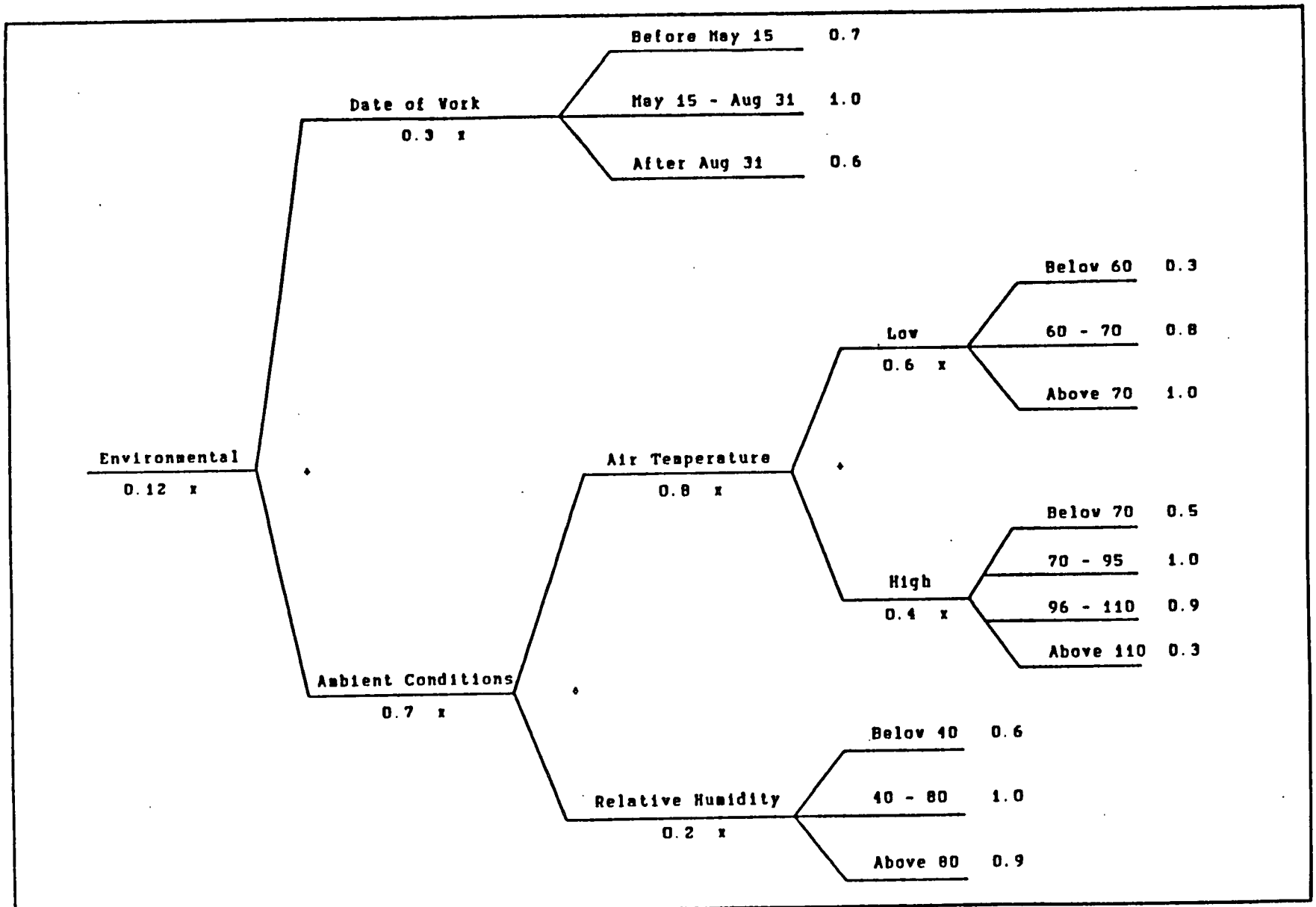


Figure 3. Chip Seal Environmental Main Attribute Branch

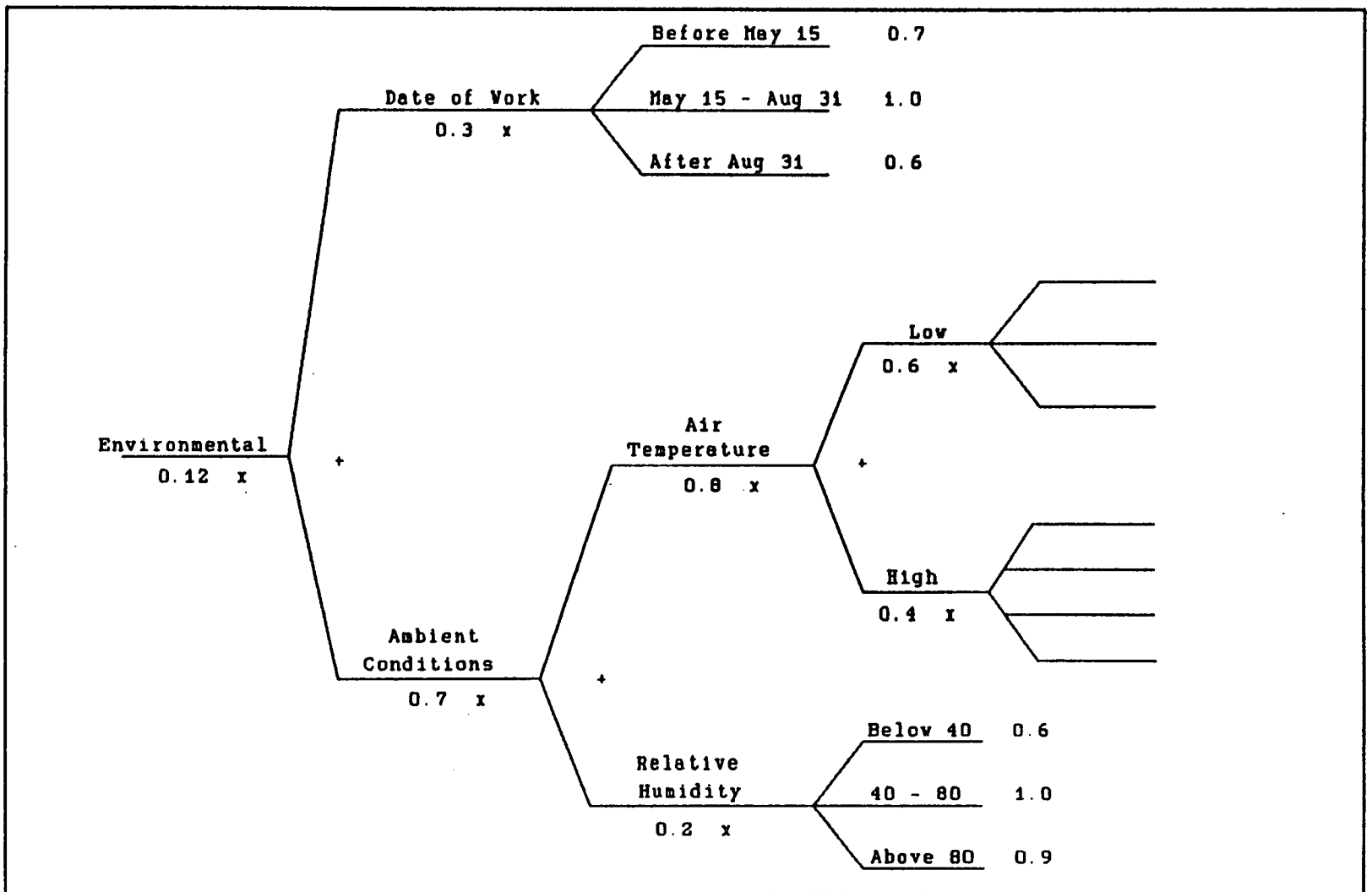


Figure 3. Chip Seal Environmental Main Attribute Branch

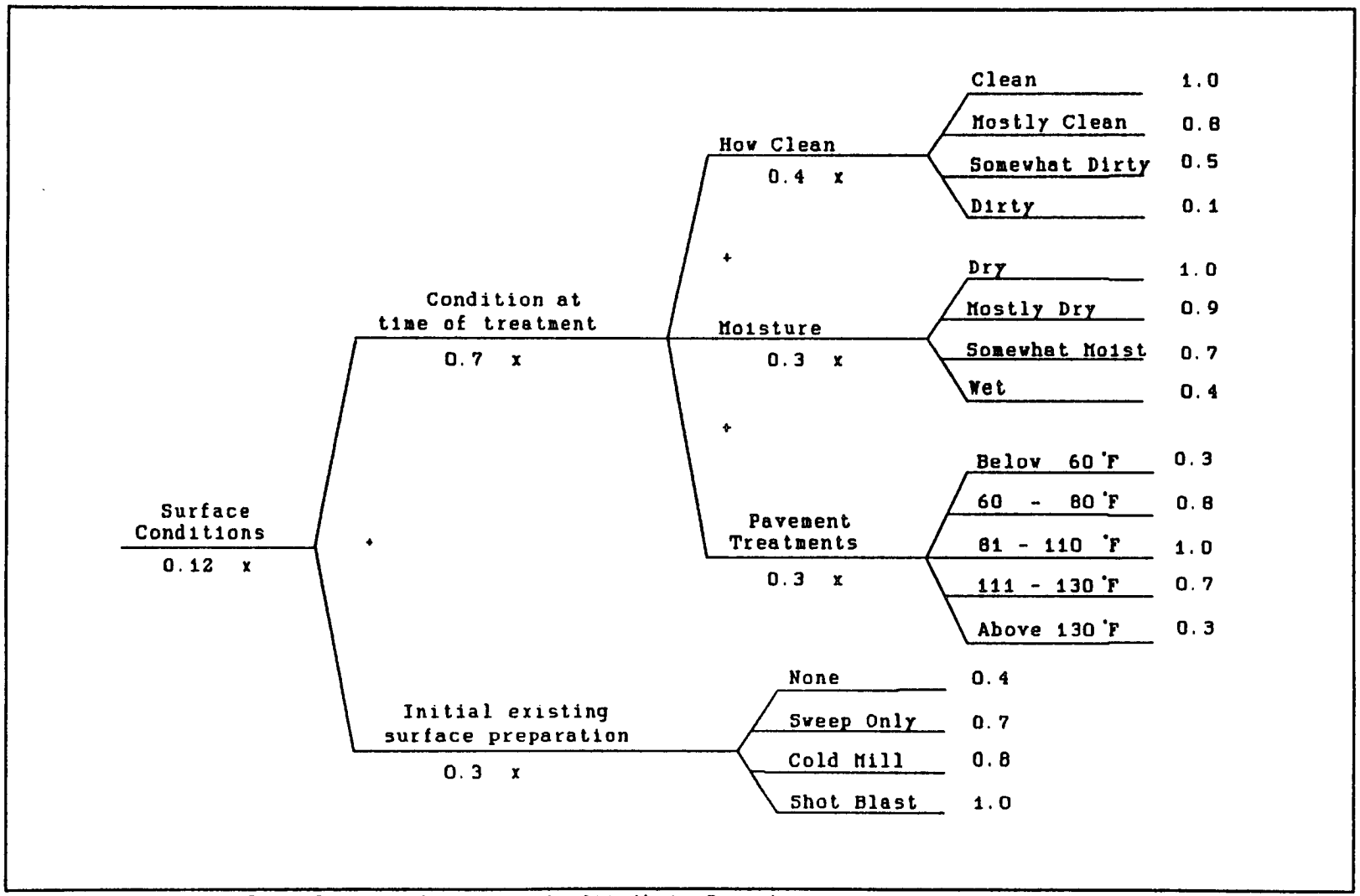


**Figure 4.** Chip Seal Surface Conditions Main Attribute Branch

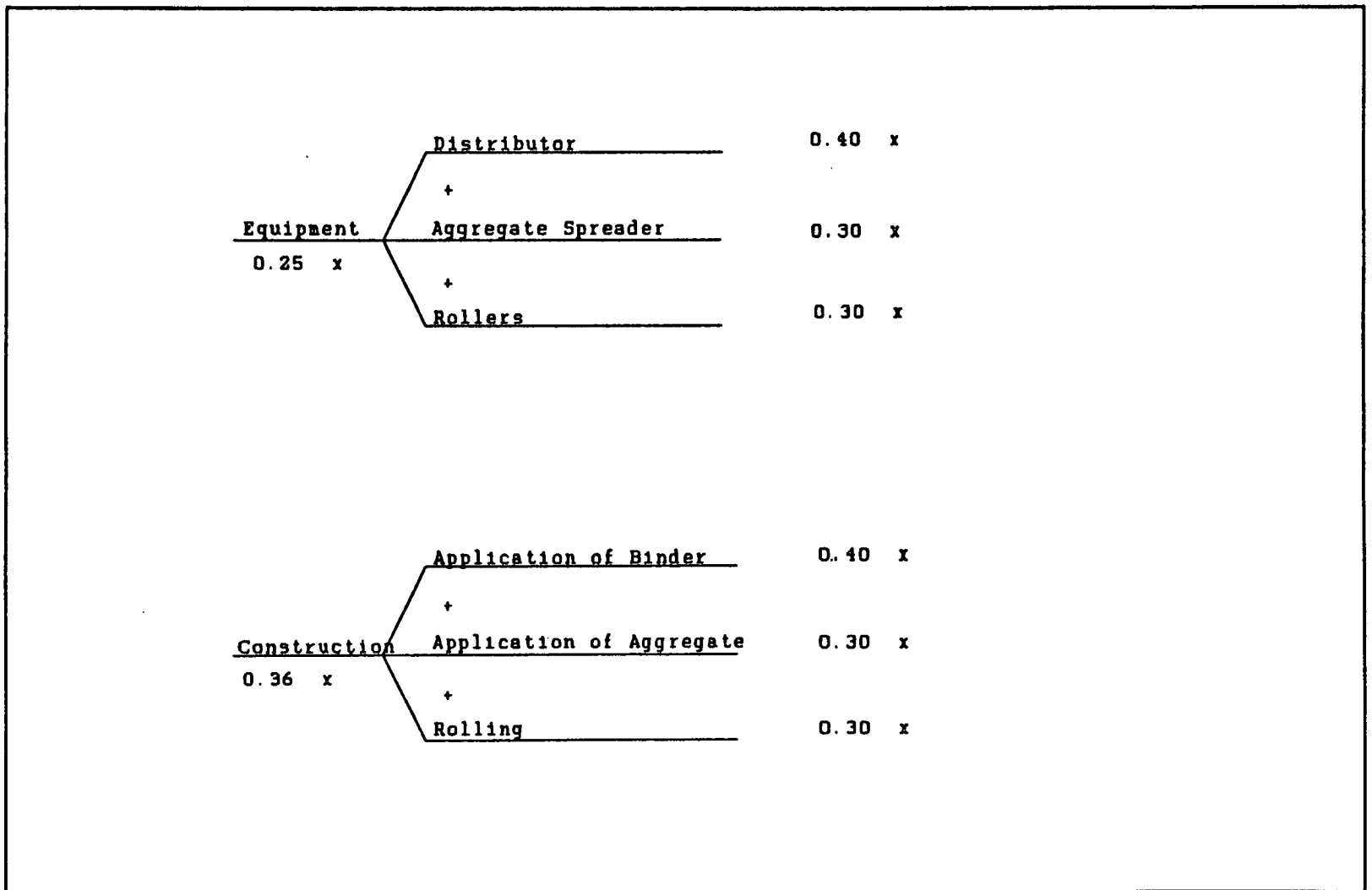


Figure 5. Chip Seal Equipment and Construction Main Attribute Branches

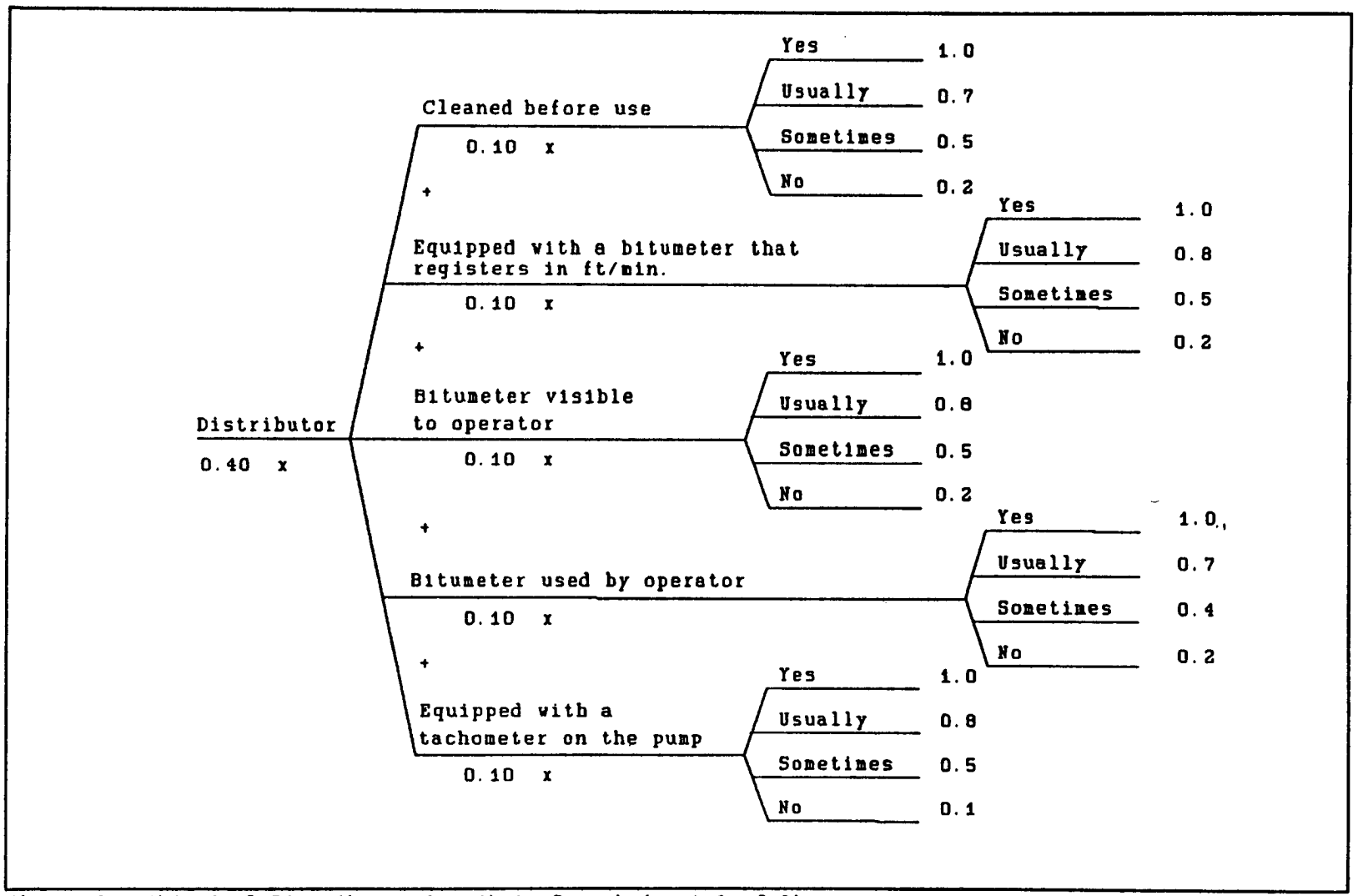


Figure 6. Chip Seal Distributor Attribute Branch (part 1 of 2)

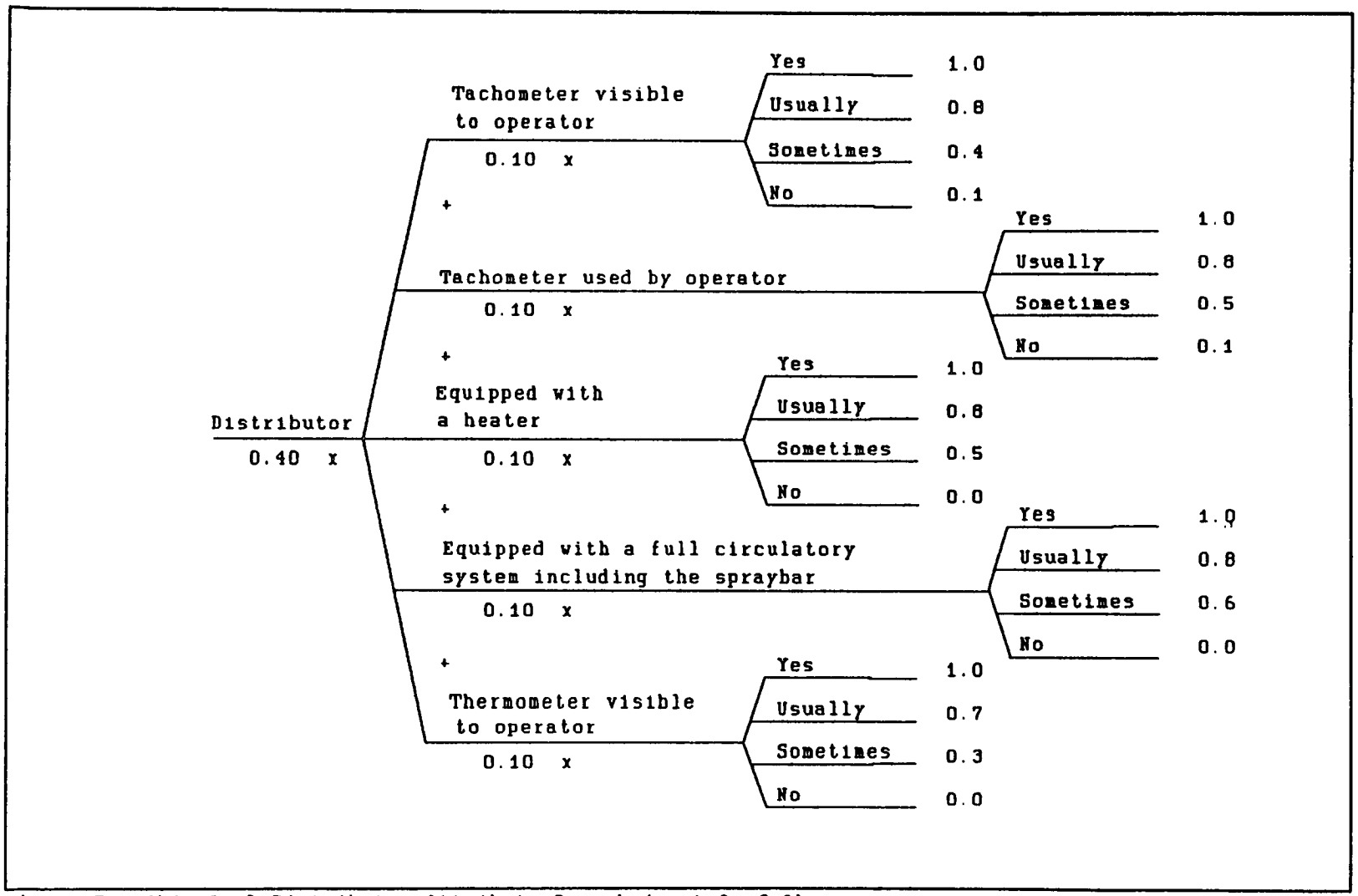


Figure 7. Chip Seal Distributor Attribute Branch (part 2 of 2)

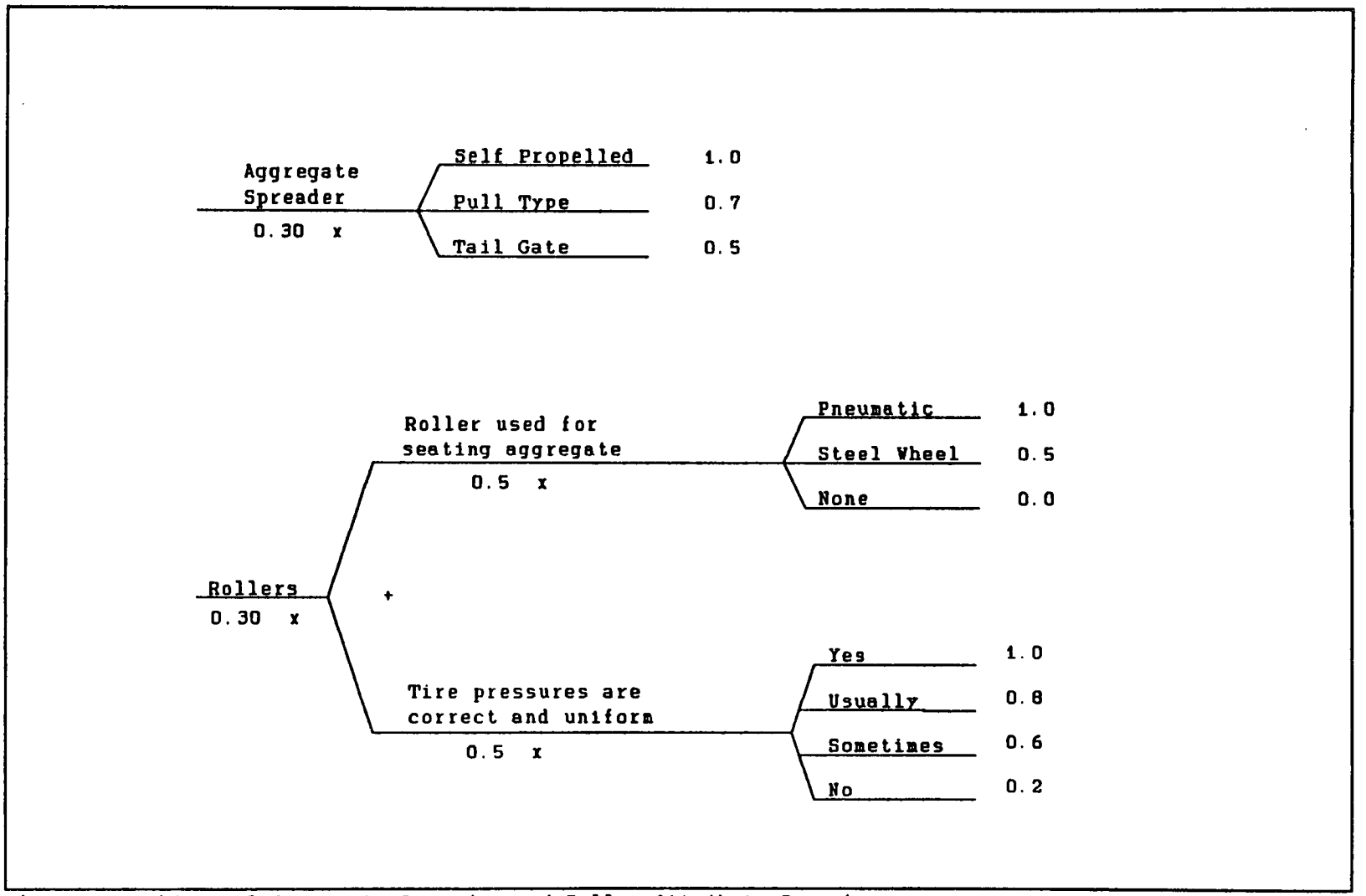


Figure 8. Chip Seal Aggregate Spreader and Roller Attribute Branches

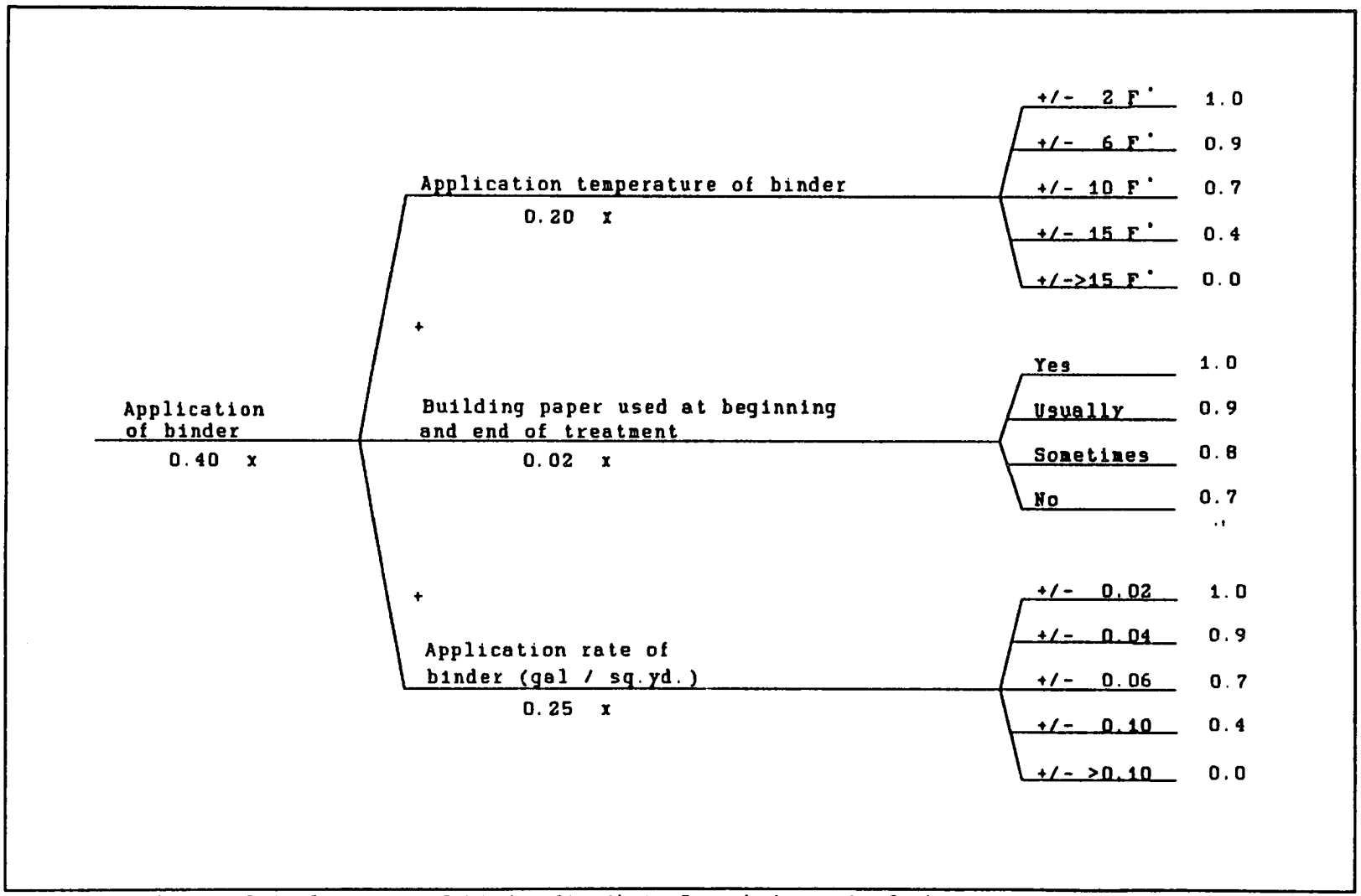


Figure 9. Chip Seal Application of Binder Attribute Branch (part 1 of 2)

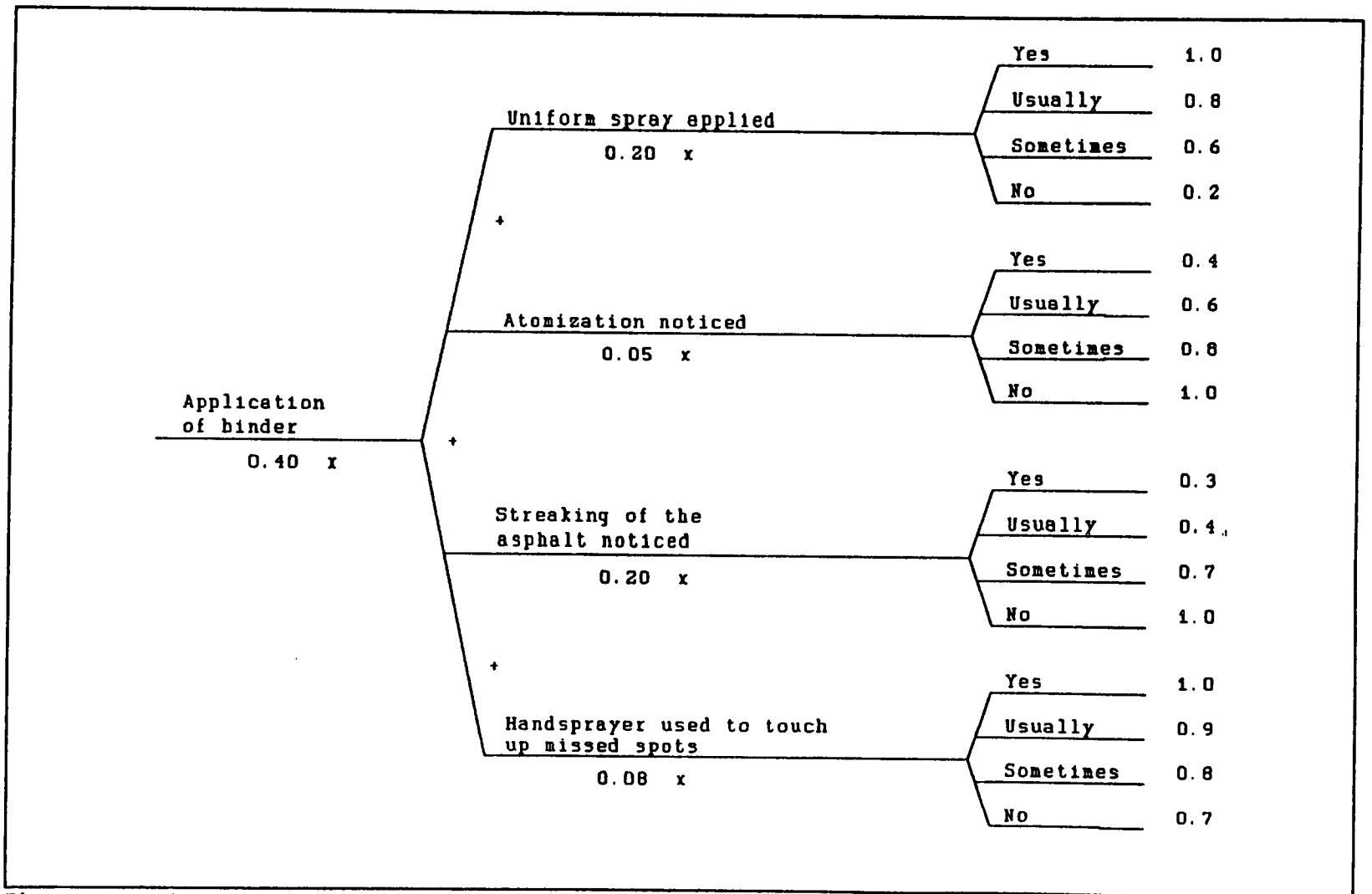


Figure 10. Chip Seal Application of Binder Attribute Branch (part 2 of 2)

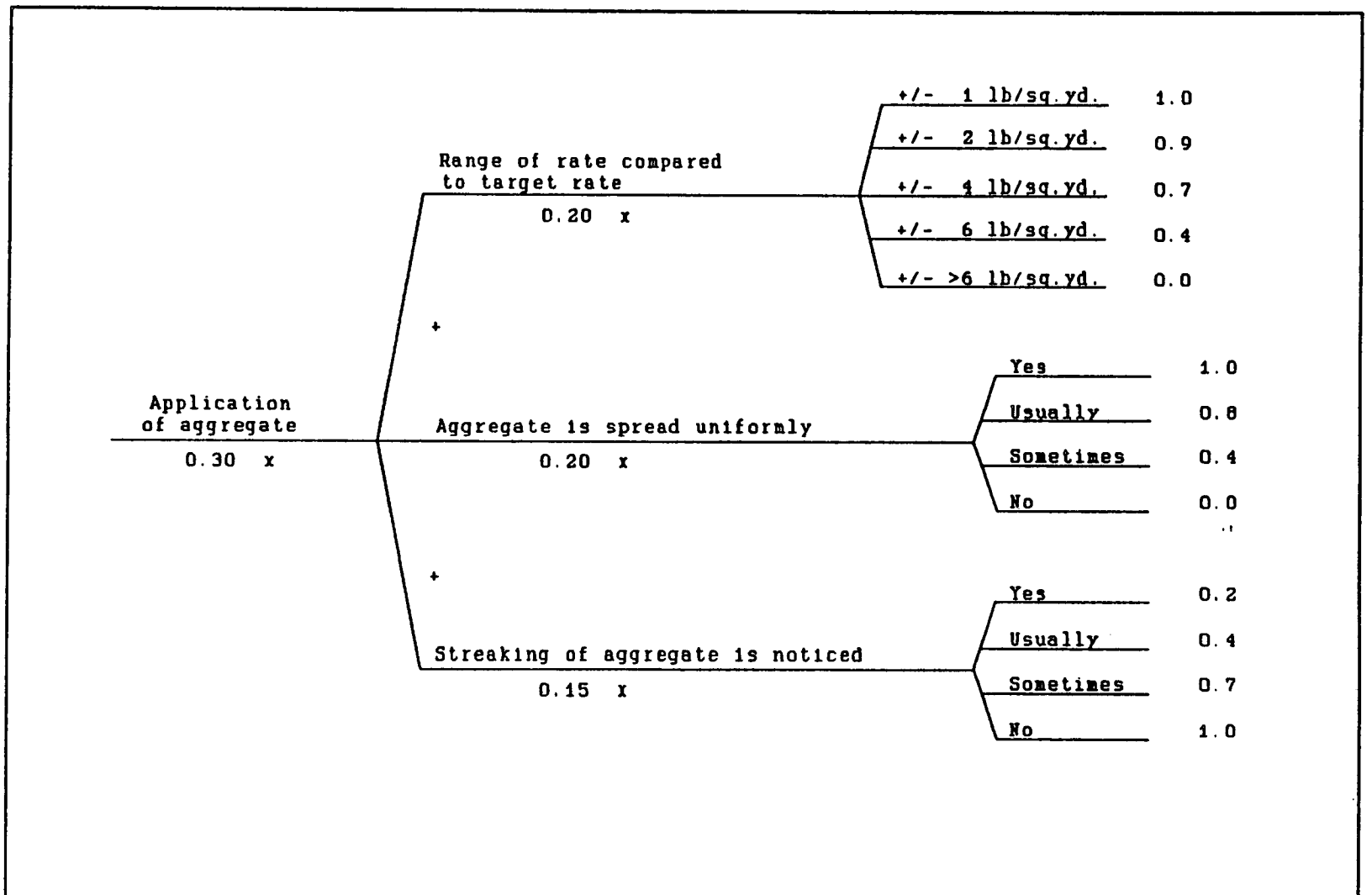


Figure 11. Chip Seal Application of Aggregate Attribute Branch (part 1 of 2)

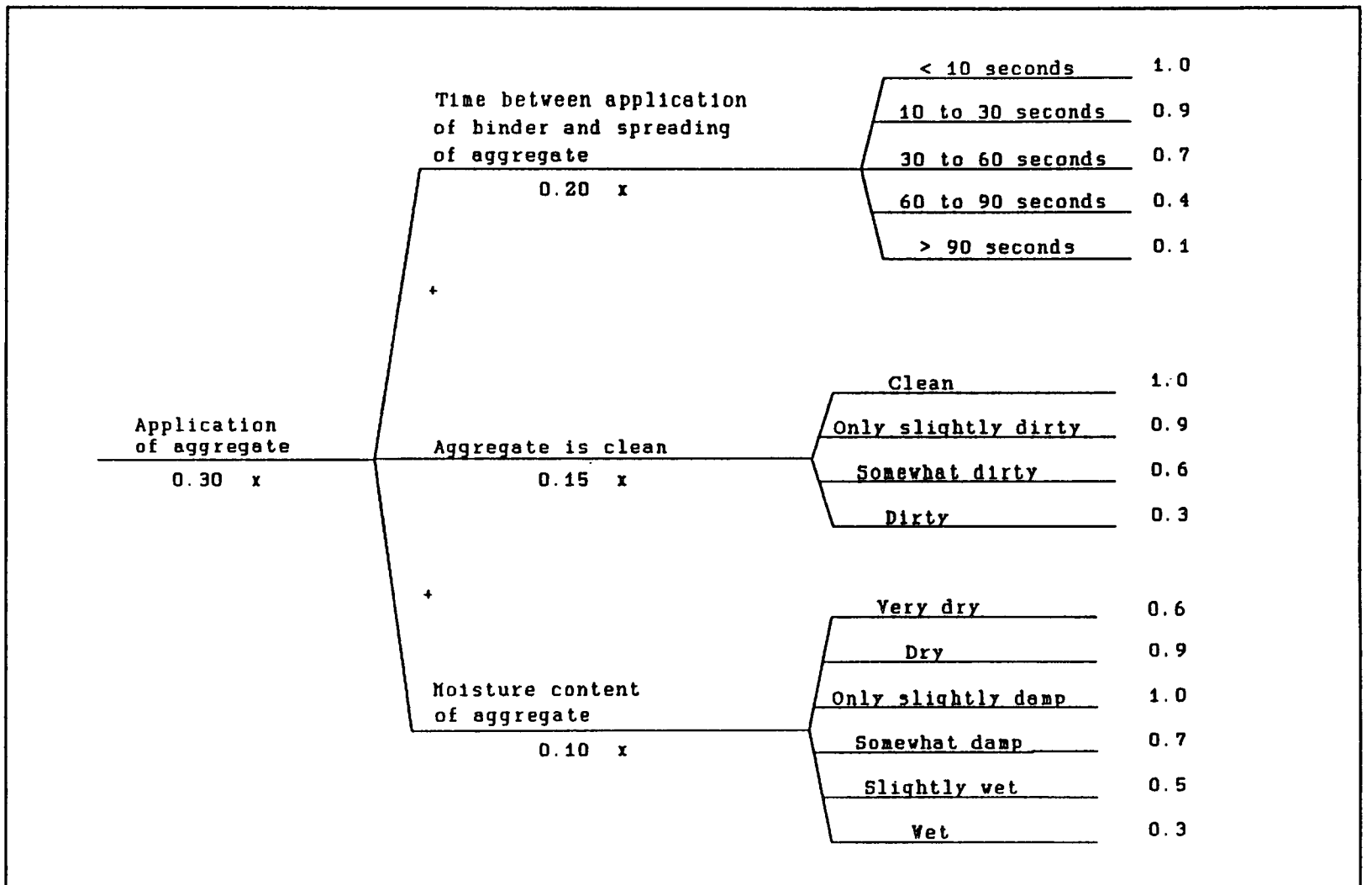


Figure 12. Chip Seal Application of Aggregate Attribute Branch (part 2 of 2)

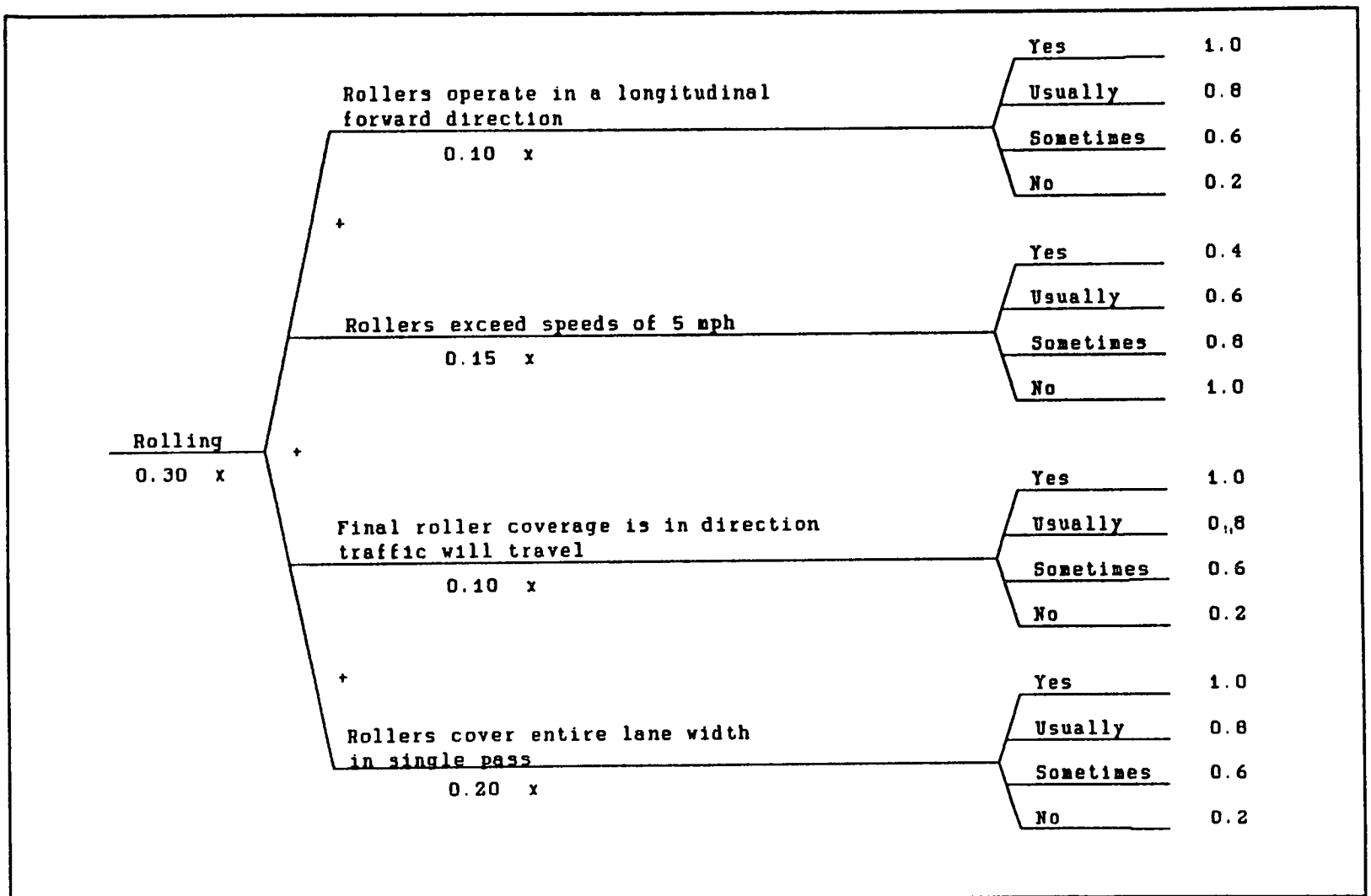


Figure 13. Chip Seal Rolling Attribute Branch (part 1 of 2)

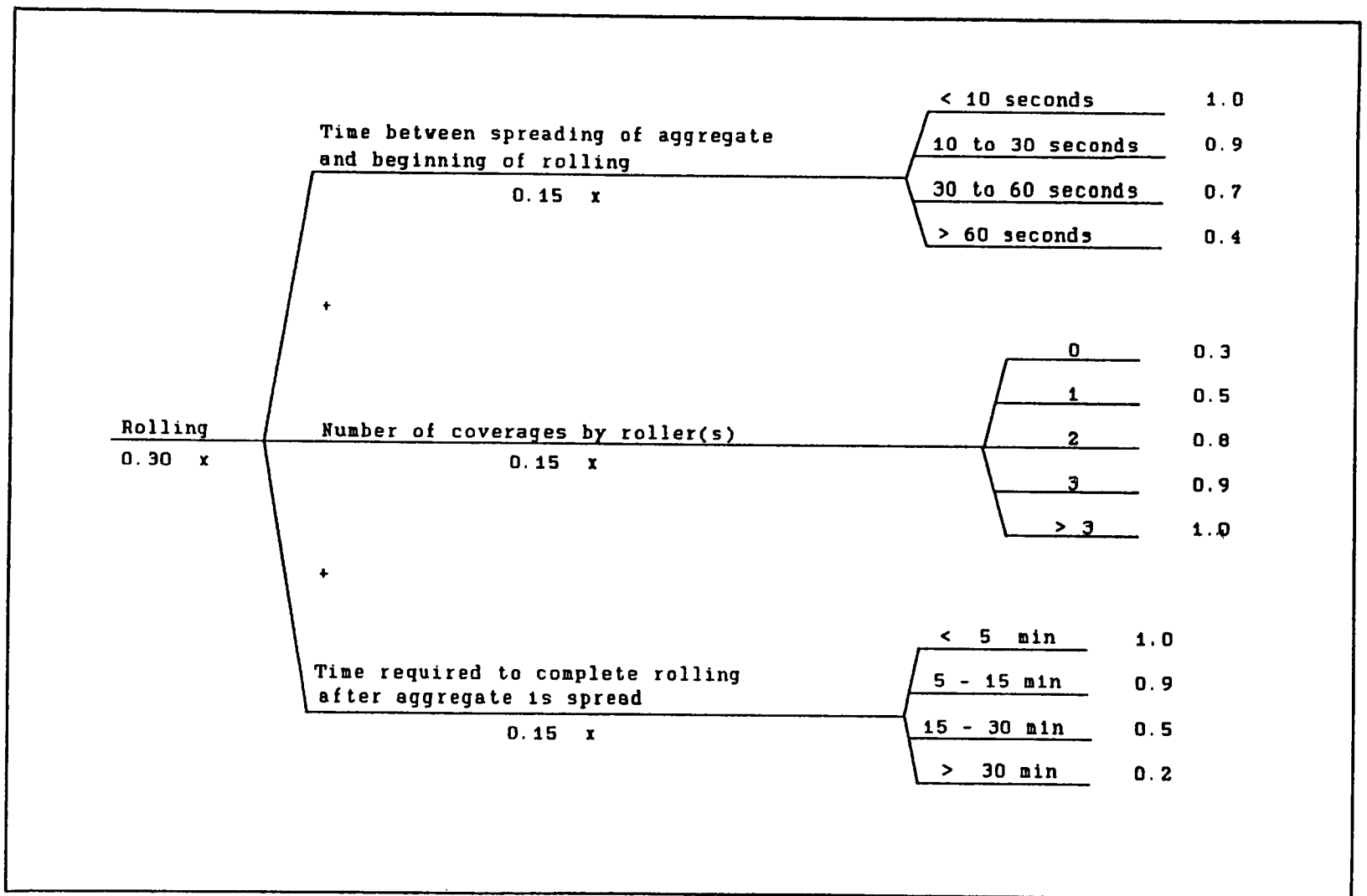


Figure 14. Chip Seal Rolling Attribute Branch (part 2 of 2)

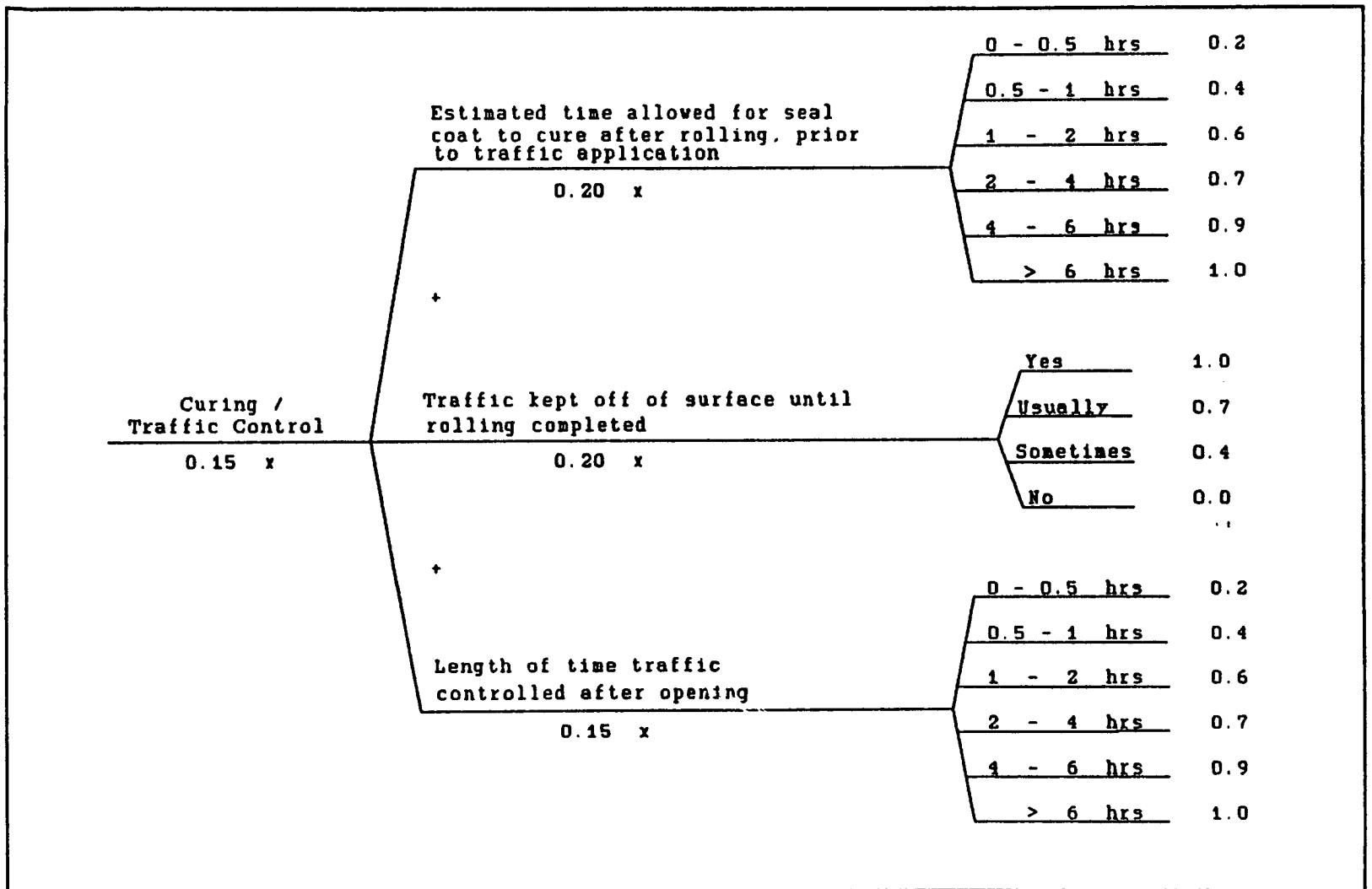


Figure 15. Chip Seal Curing / Traffic Control Main Attribute Branch (part 1 of 2)

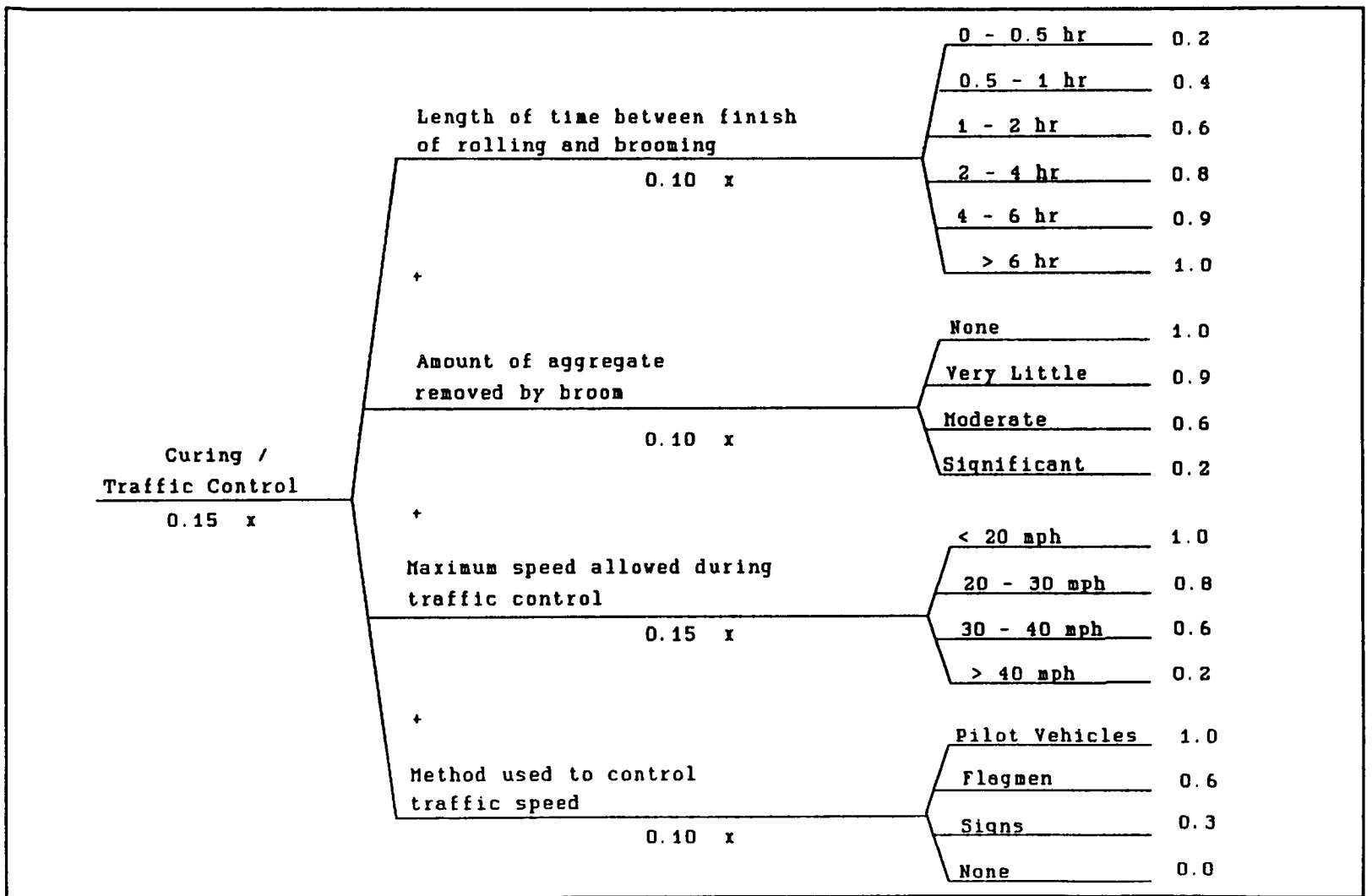


Figure 16. Chip Seal Curing / Traffic Control Main Attribute Branch (part 2 of 2)

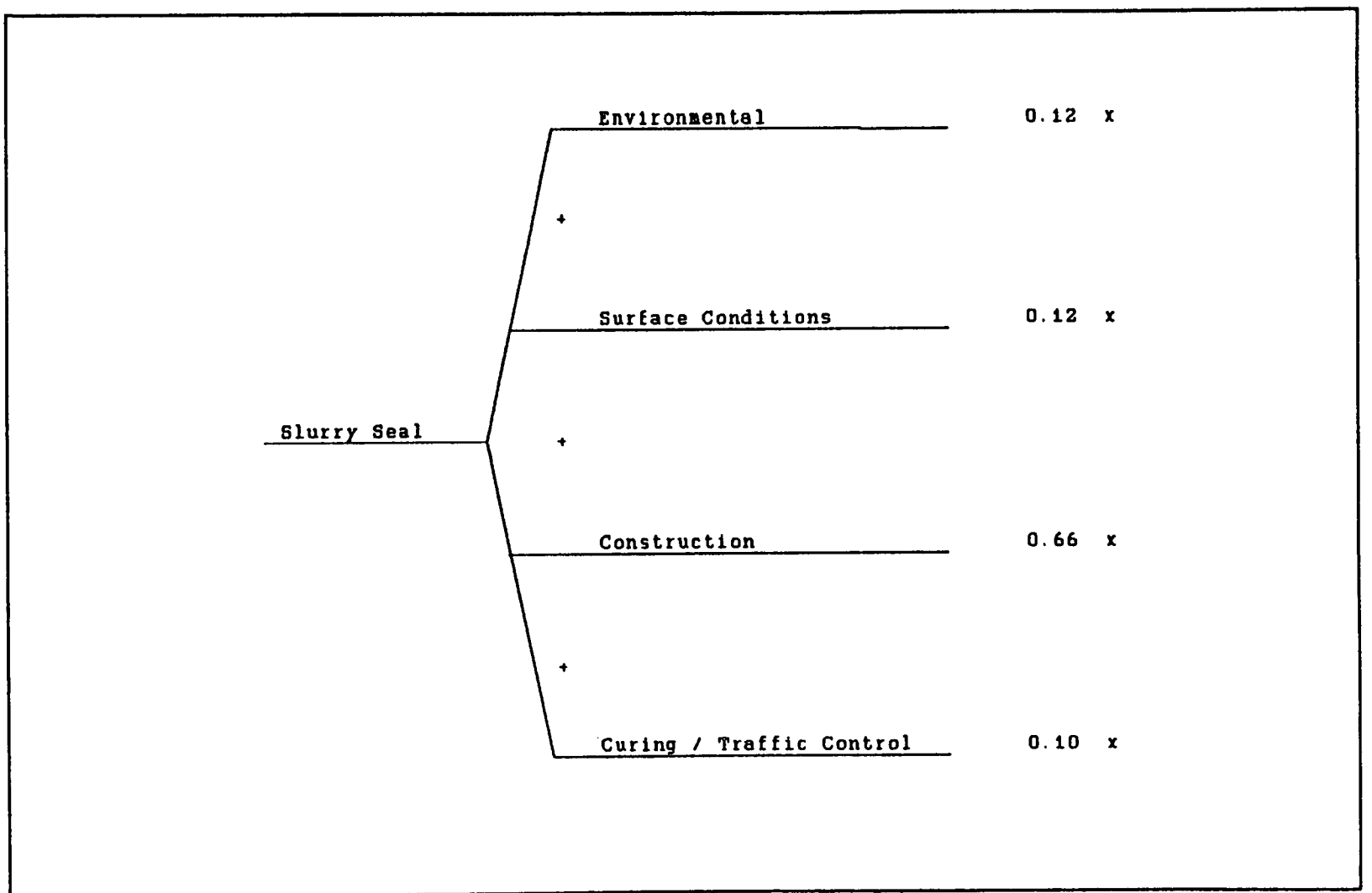


Figure 17. Slurry Seal Rating Tree Main Attribute Branches

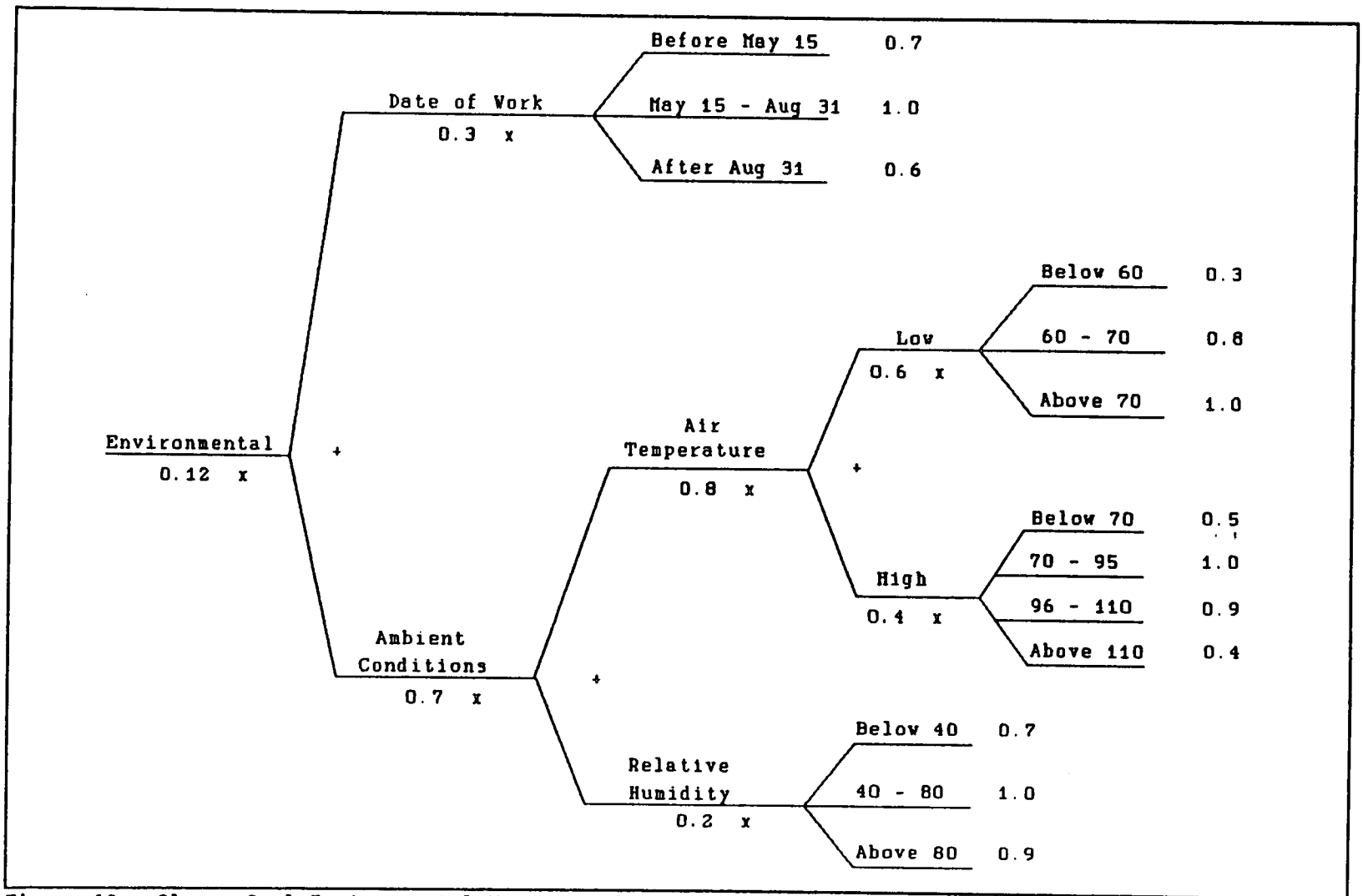


Figure 18. Slurry Seal Environmental Main Branch Attribute

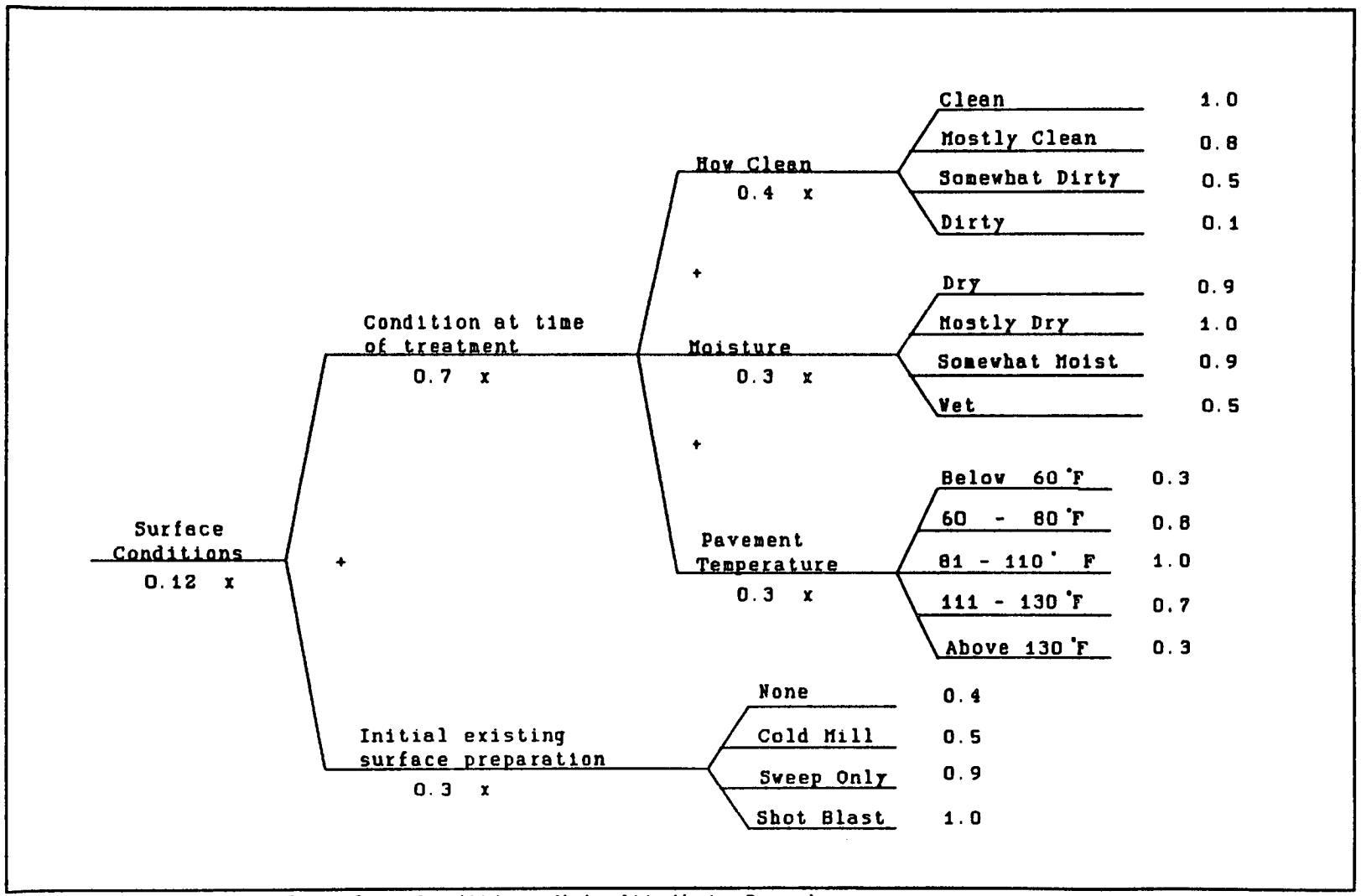


Figure 19. Slurry Seal Surface Conditions Main Attribute Branch

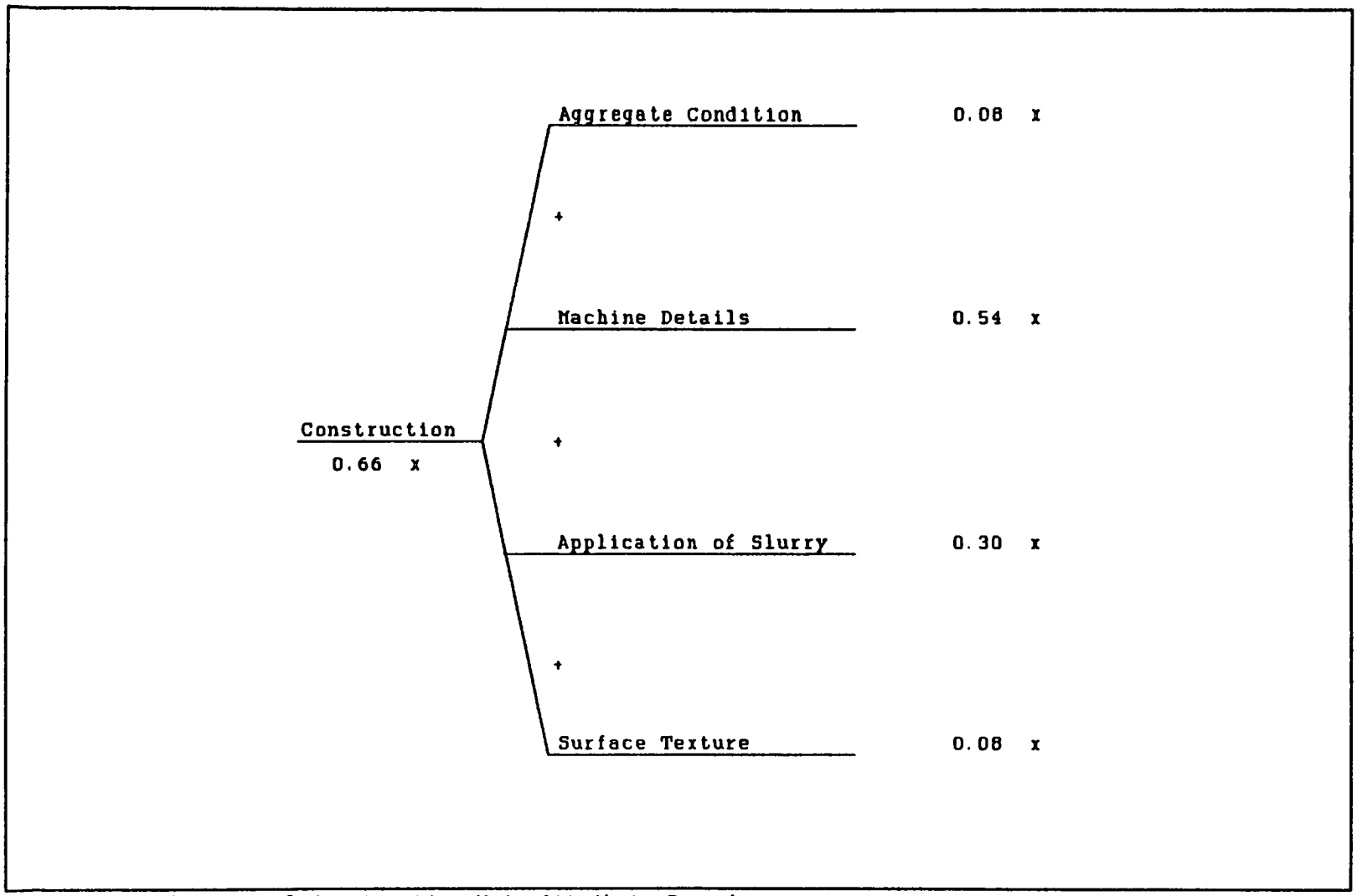


Figure 20. Slurry Seal Construction Main Attribute Branch

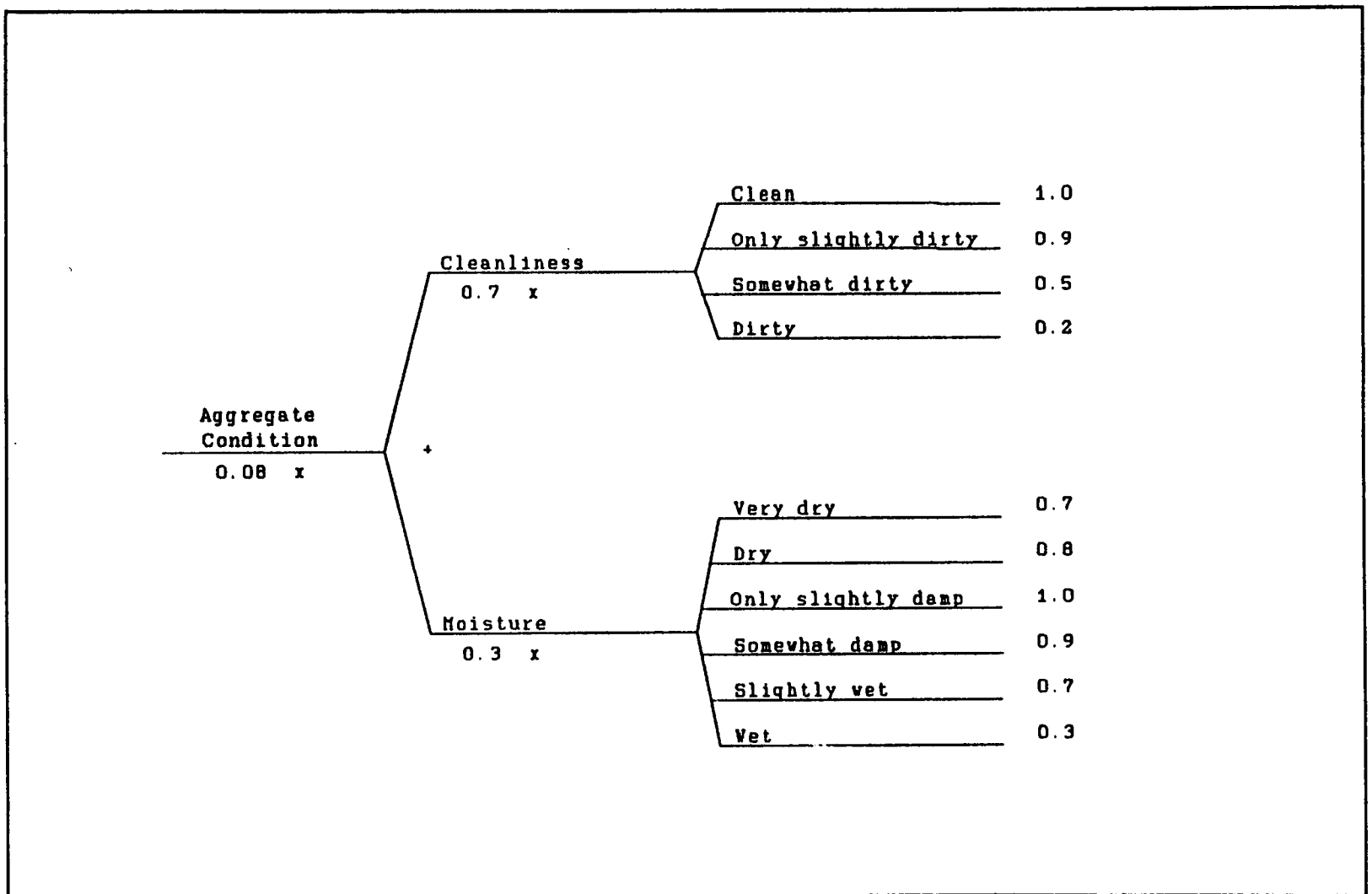


Figure 21. Slurry Seal Aggregate Condition Attribute Branch

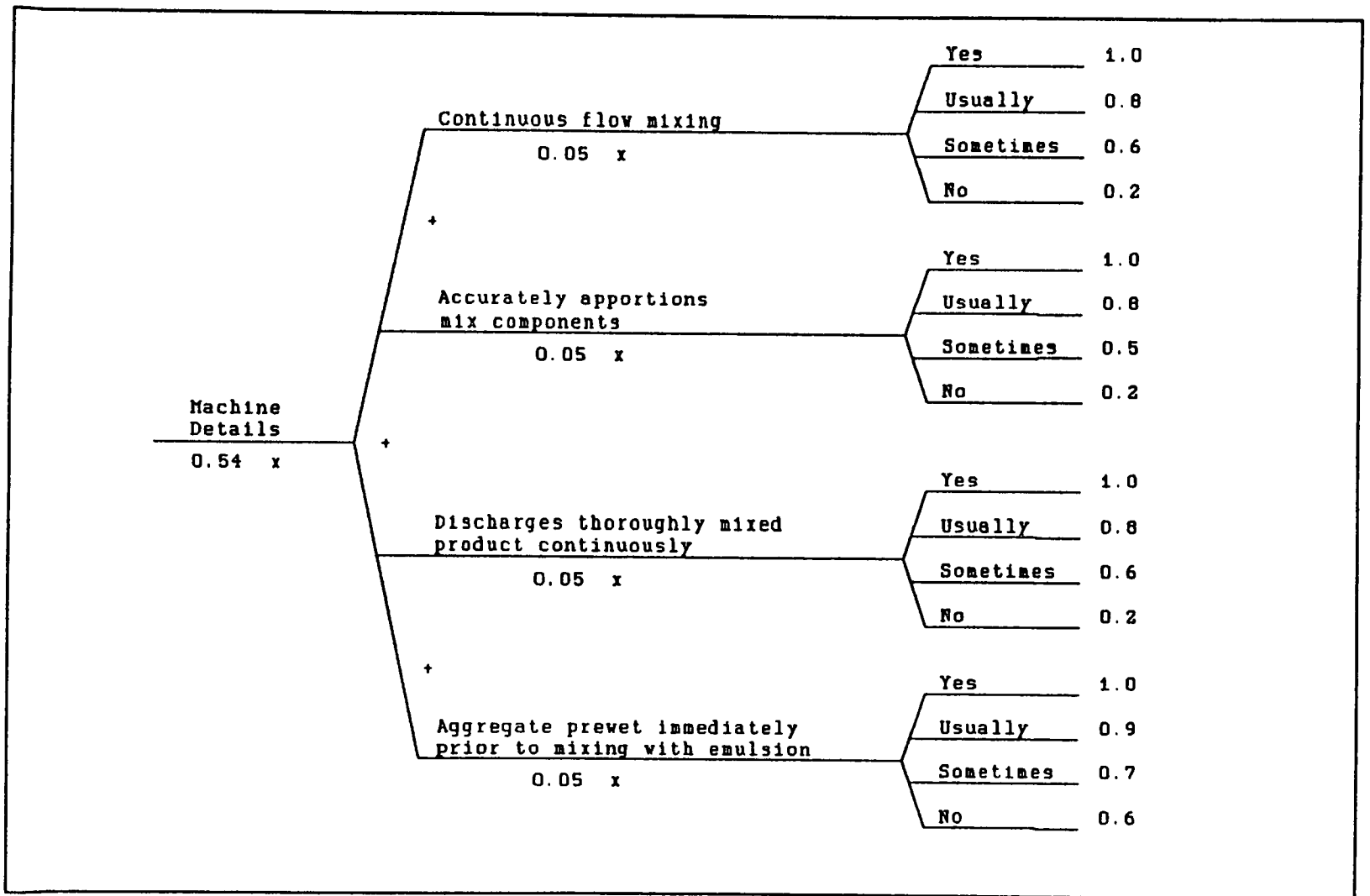


Figure 22. Slurry Seal Machine Details Attribute Branch (part 1 of 5)

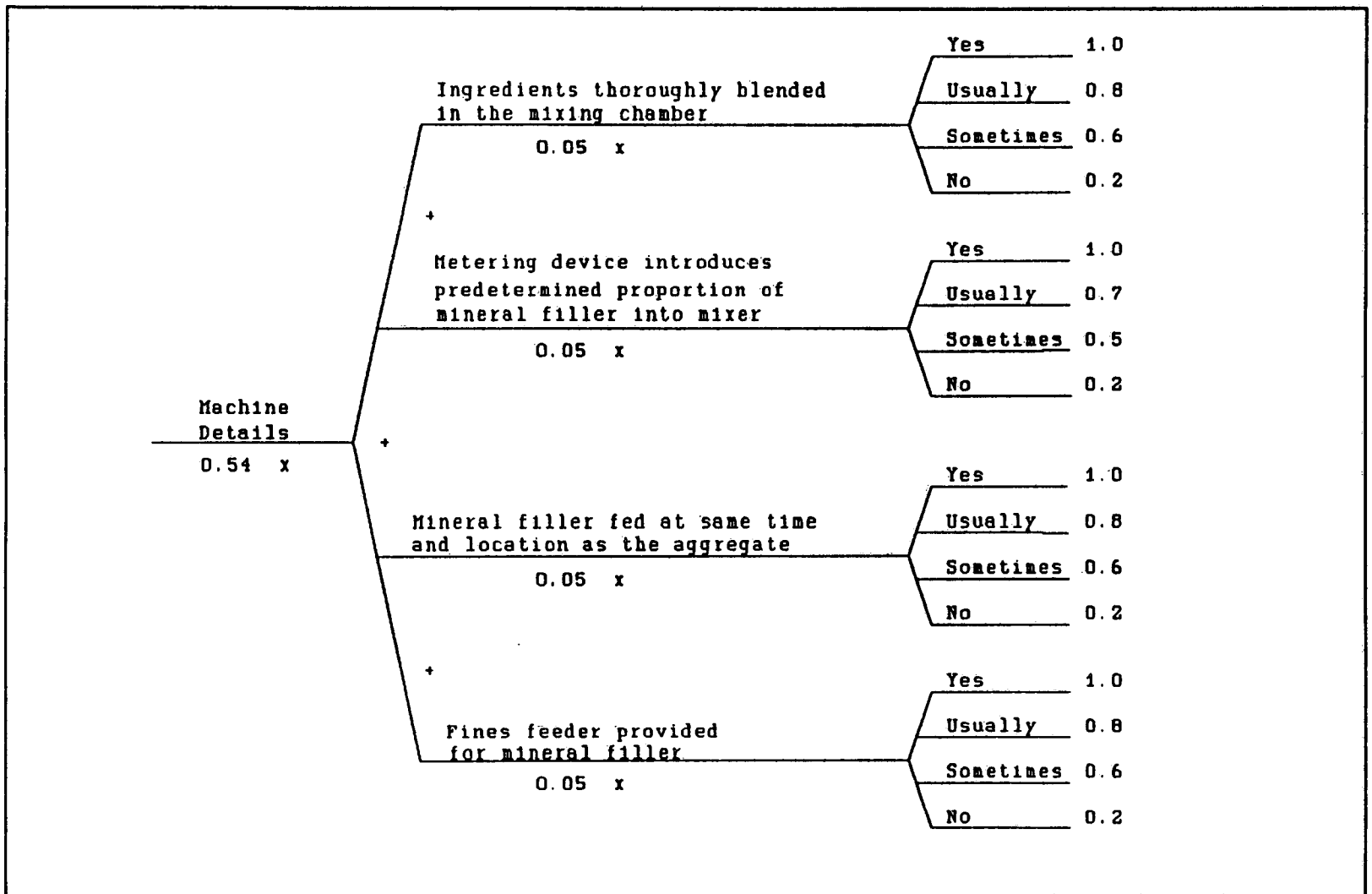


Figure 23. Slurry Seal Machine Details Attribute Branch (part 2 of 5)

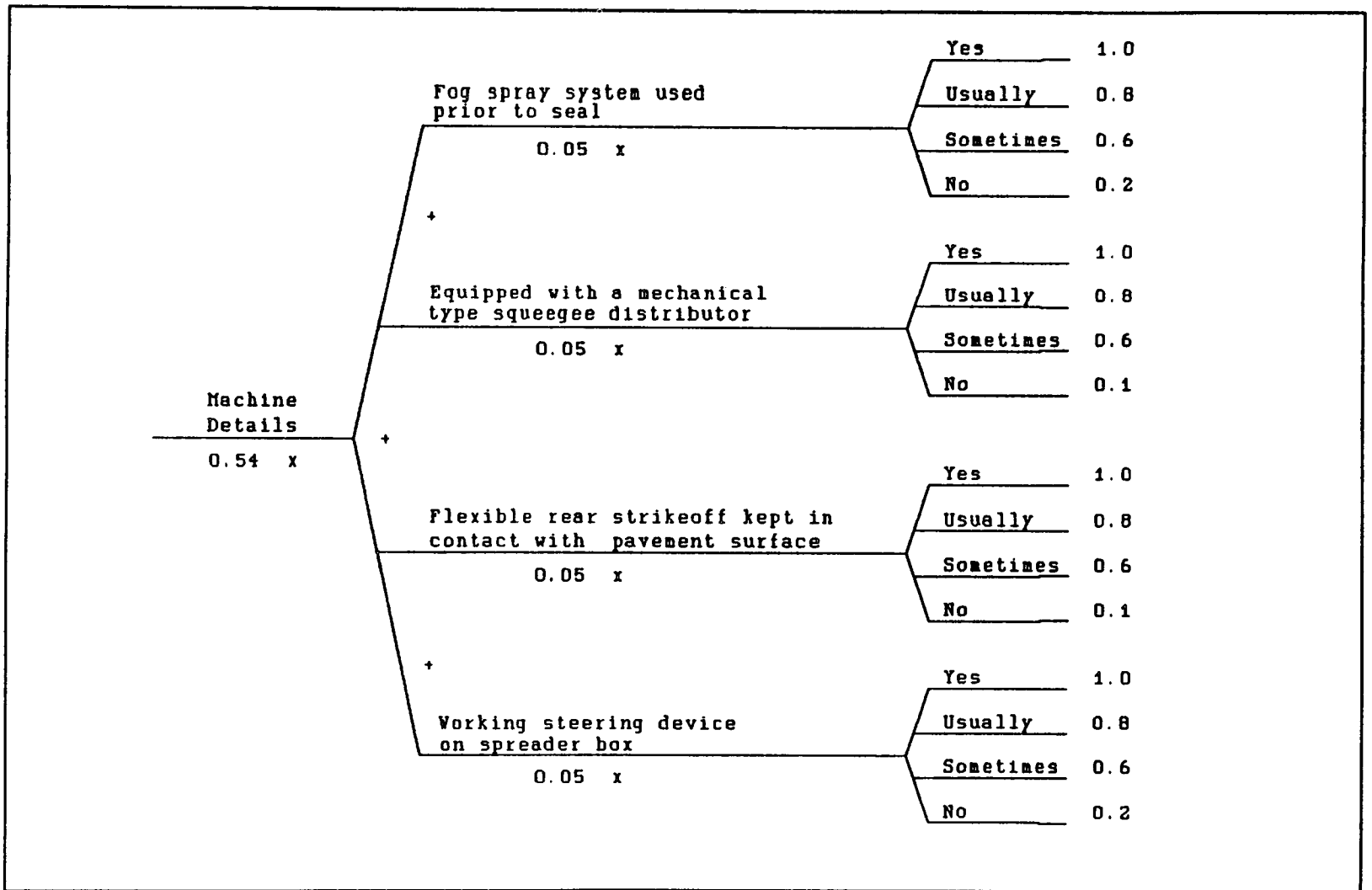


Figure 24. Slurry Seal Machine Details Attribute Branch (part 3 of 5)

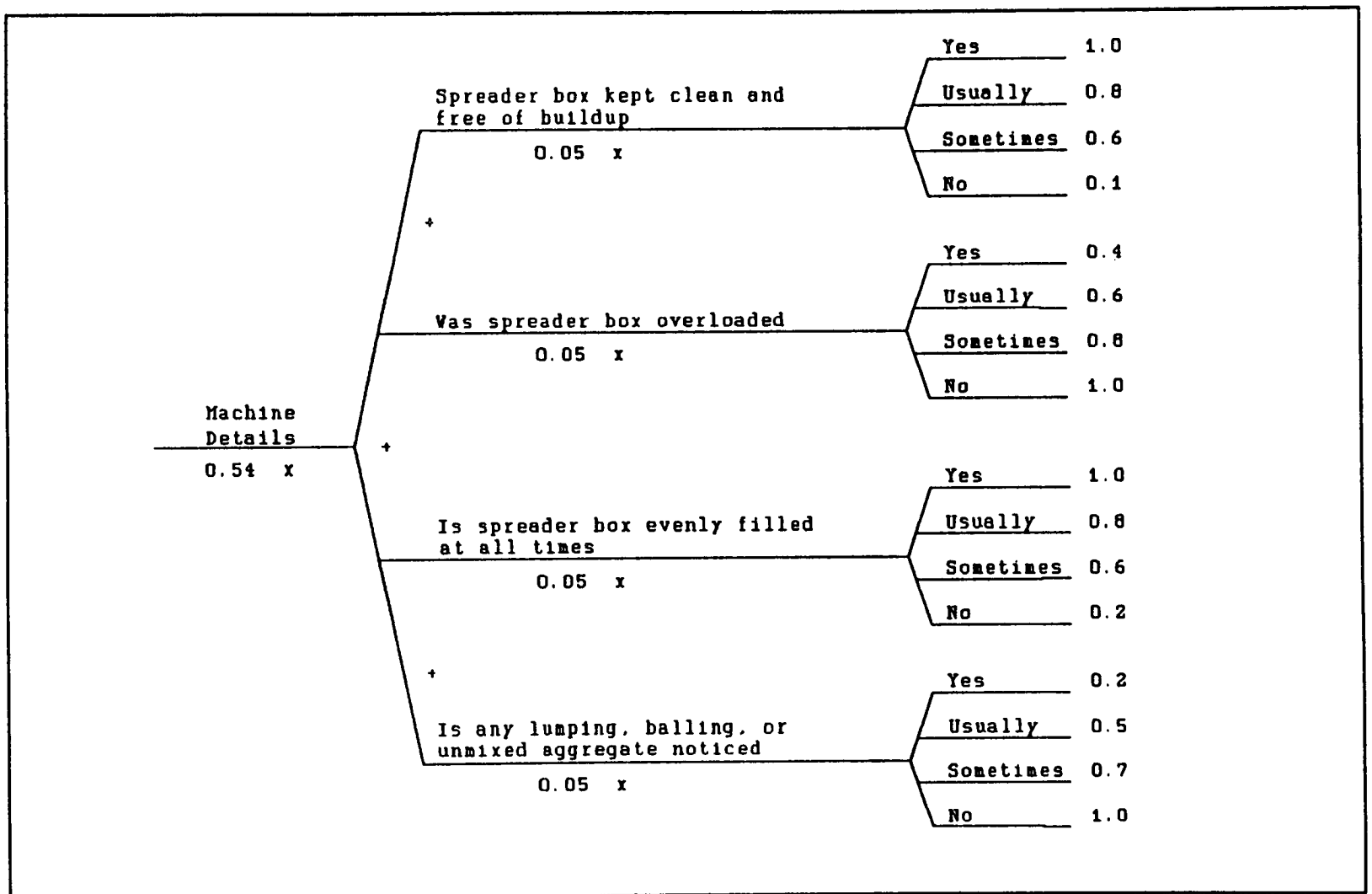


Figure 25. Slurry Seal Machine Details Attribute Branch (part 4 of 5)

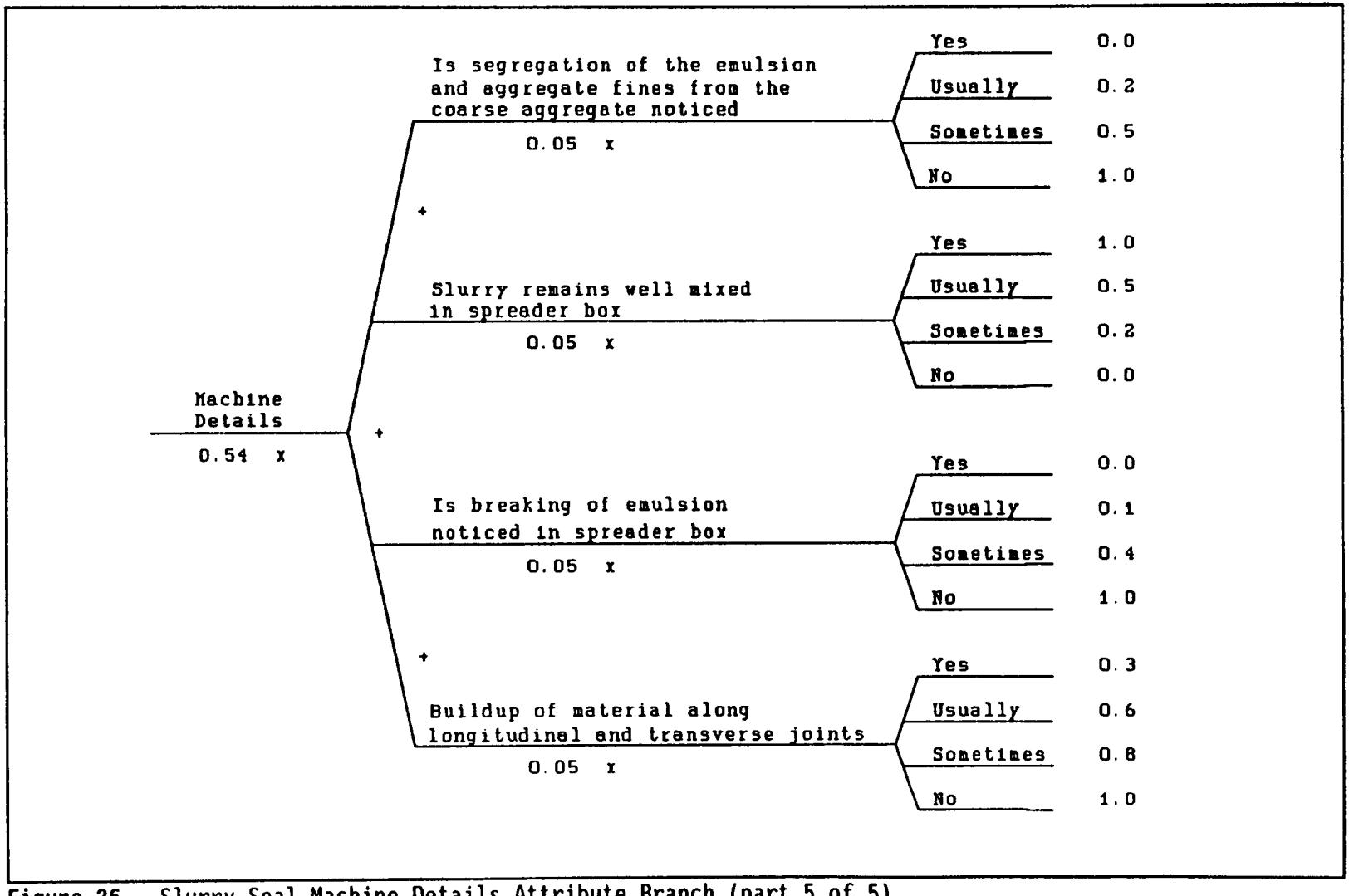


Figure 26. Slurry Seal Machine Details Attribute Branch (part 5 of 5)

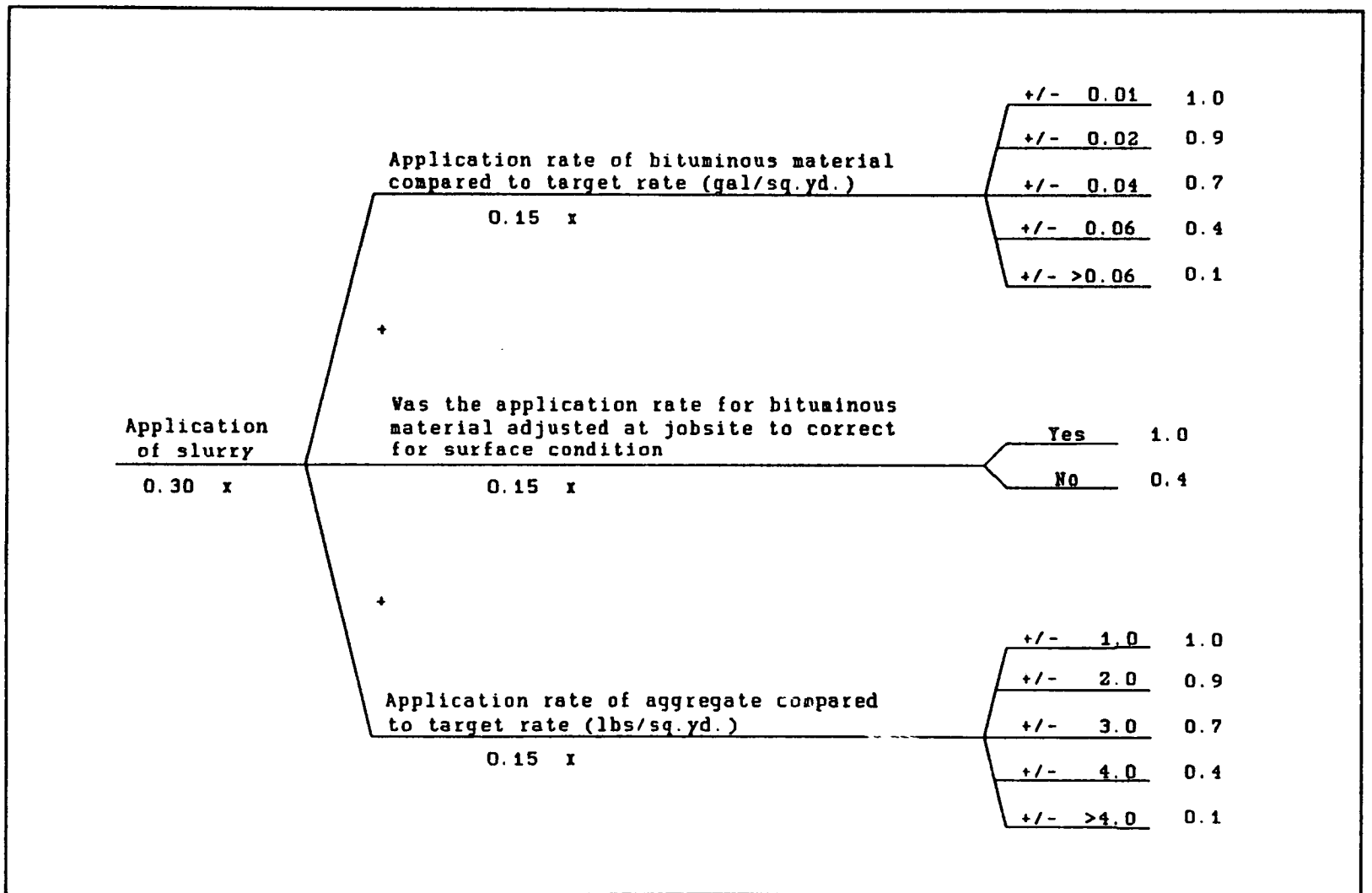


Figure 27. Slurry Seal Application of Slurry Attribute Branch (part 1 of 2)

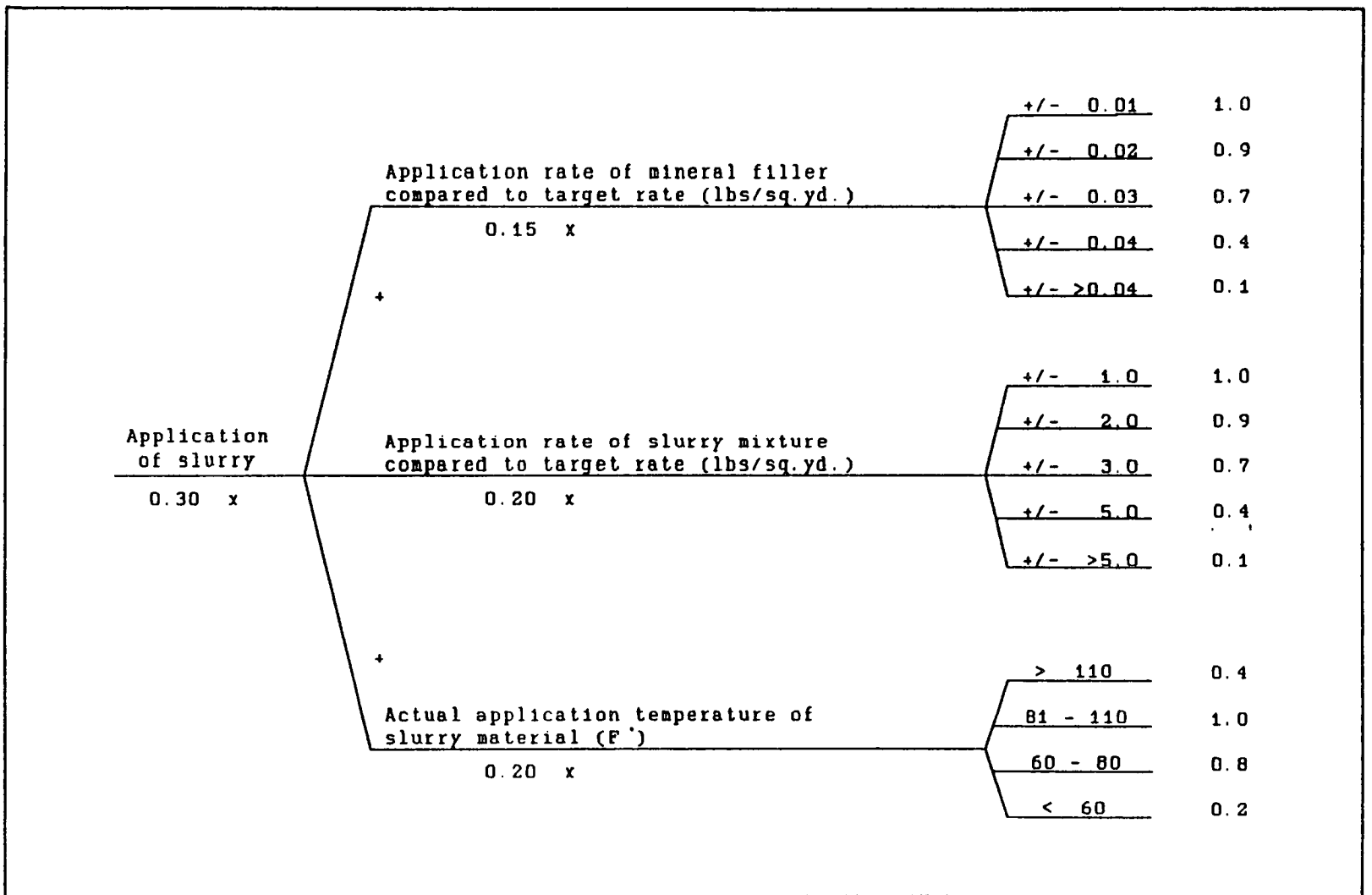


Figure 28. Slurry Seal Application of Slurry Attribute Branch (part 2 of 2)

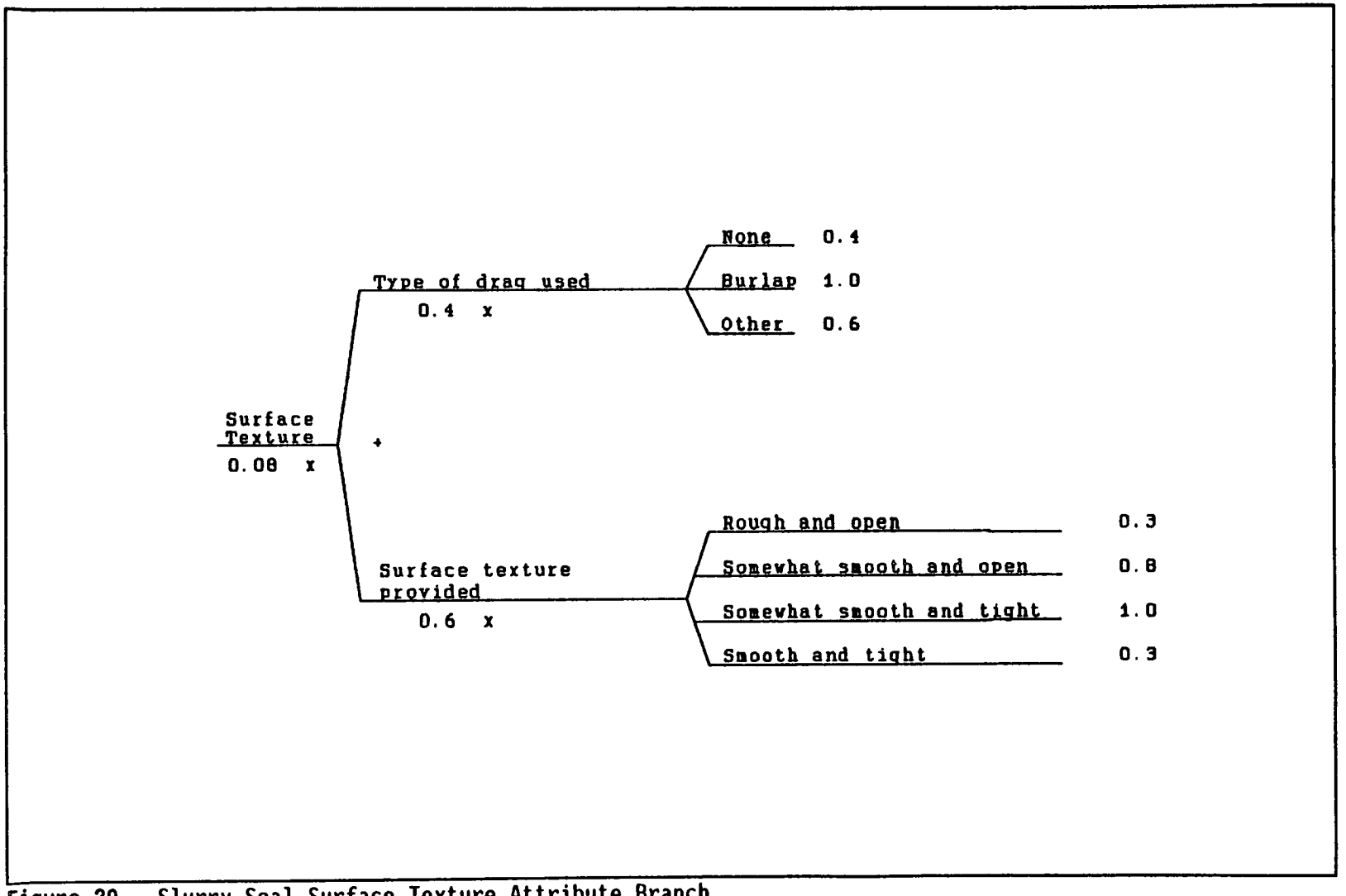


Figure 29. Slurry Seal Surface Texture Attribute Branch

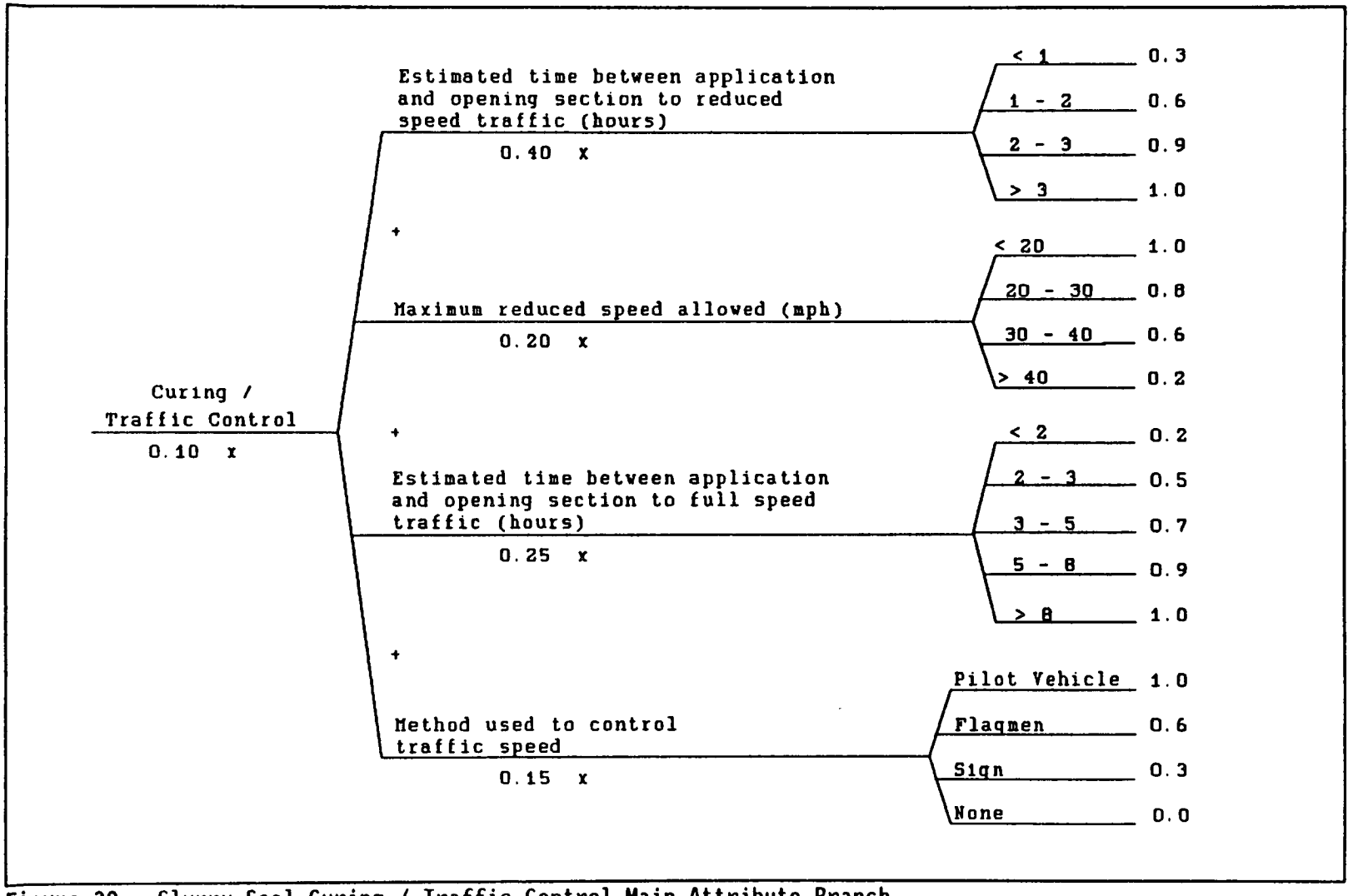


Figure 30. Slurry Seal Curing / Traffic Control Main Attribute Branch

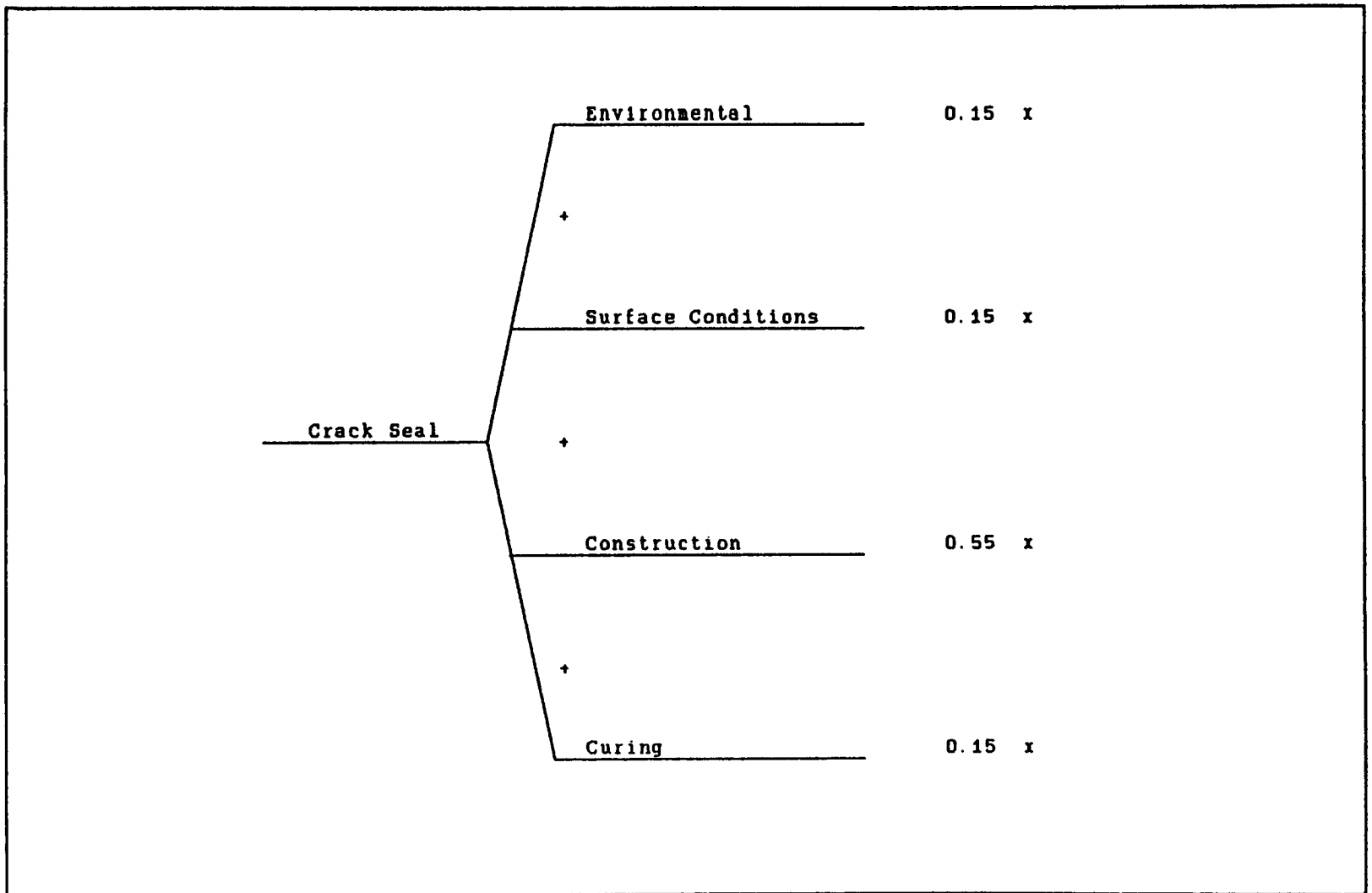


Figure 31. Crack Seal Rating Tree Main Attribute Branches

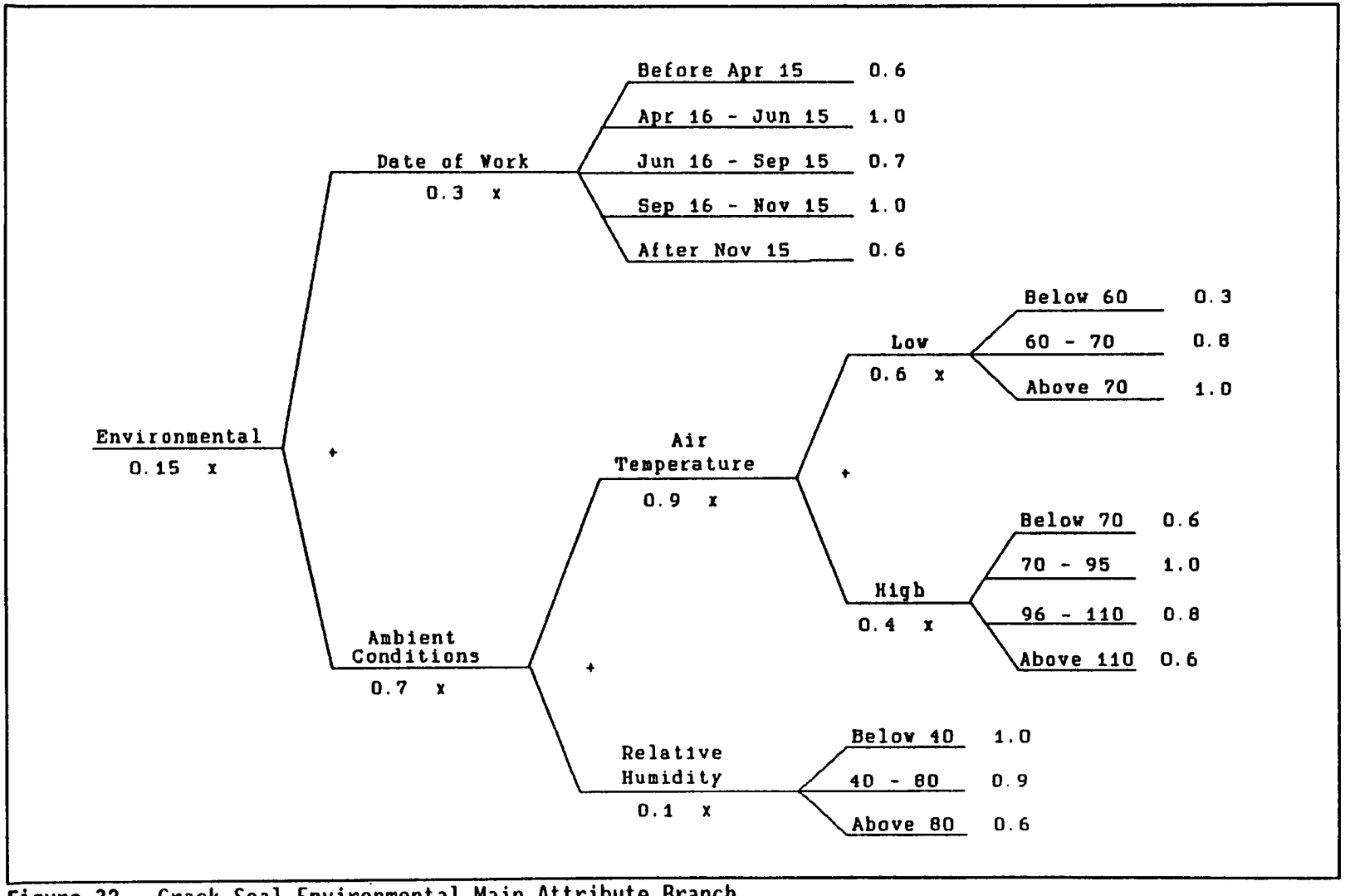


Figure 32. Crack Seal Environmental Main Attribute Branch

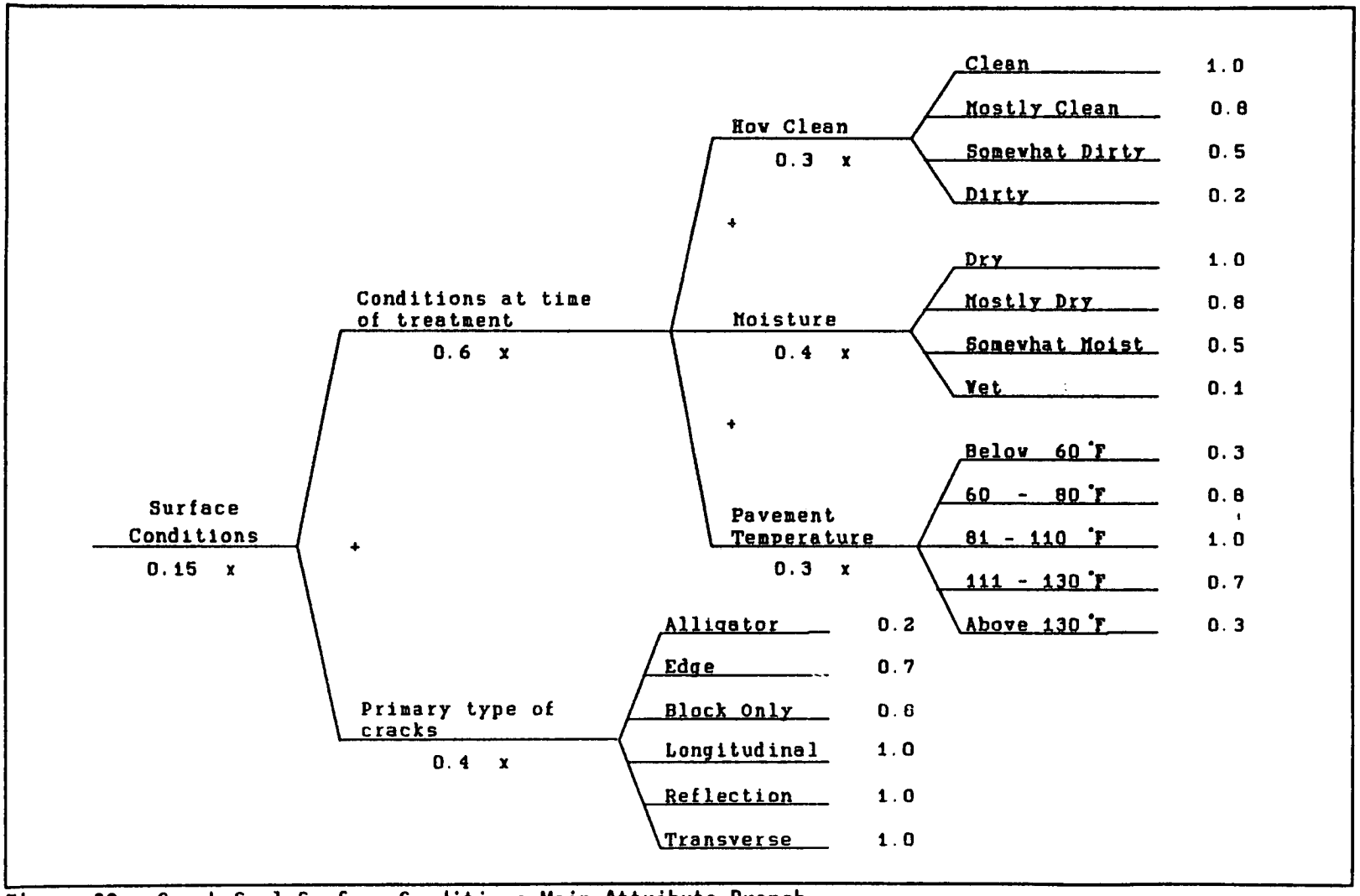


Figure 33. Crack Seal Surface Conditions Main Attribute Branch

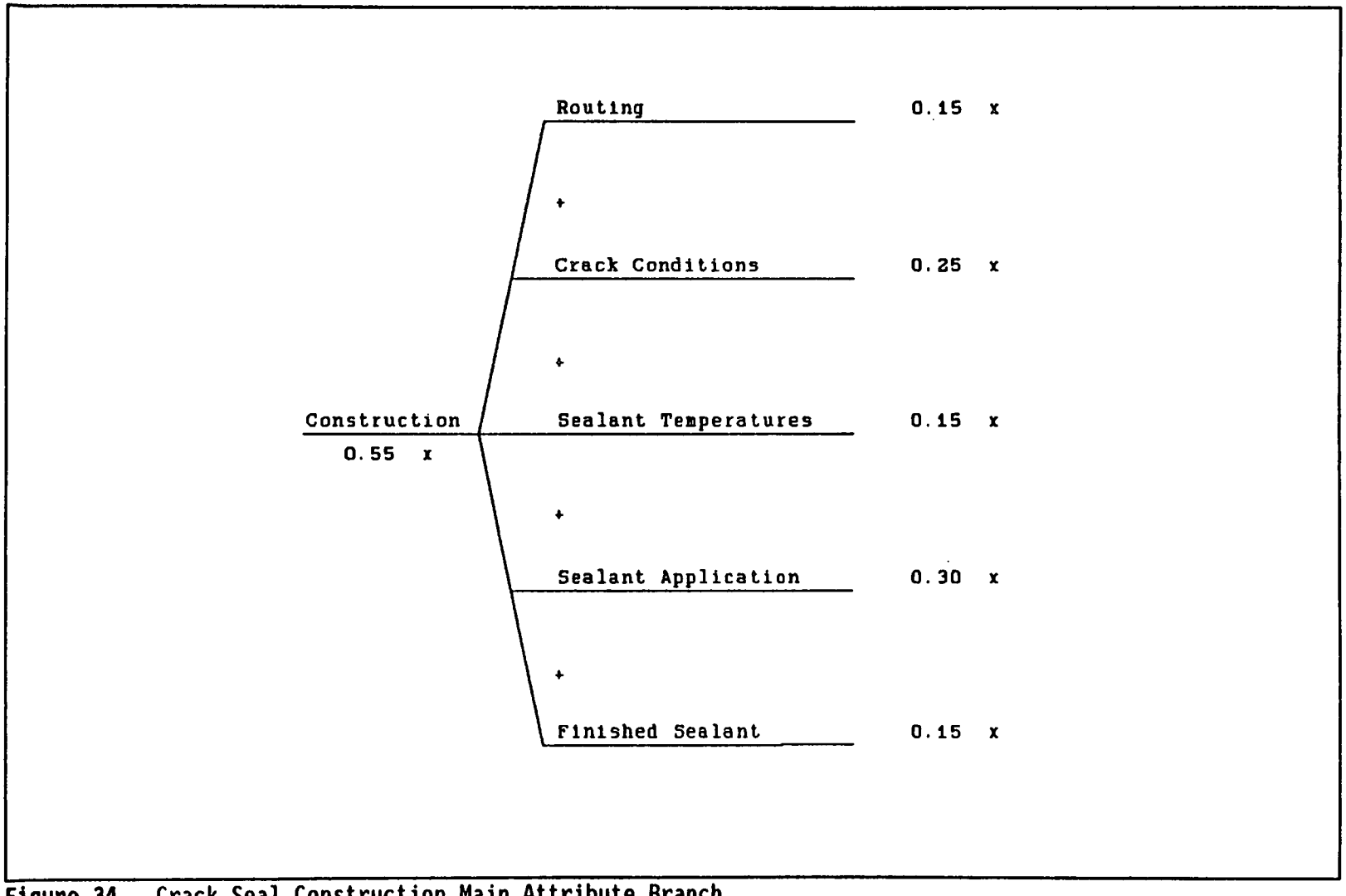


Figure 34. Crack Seal Construction Main Attribute Branch

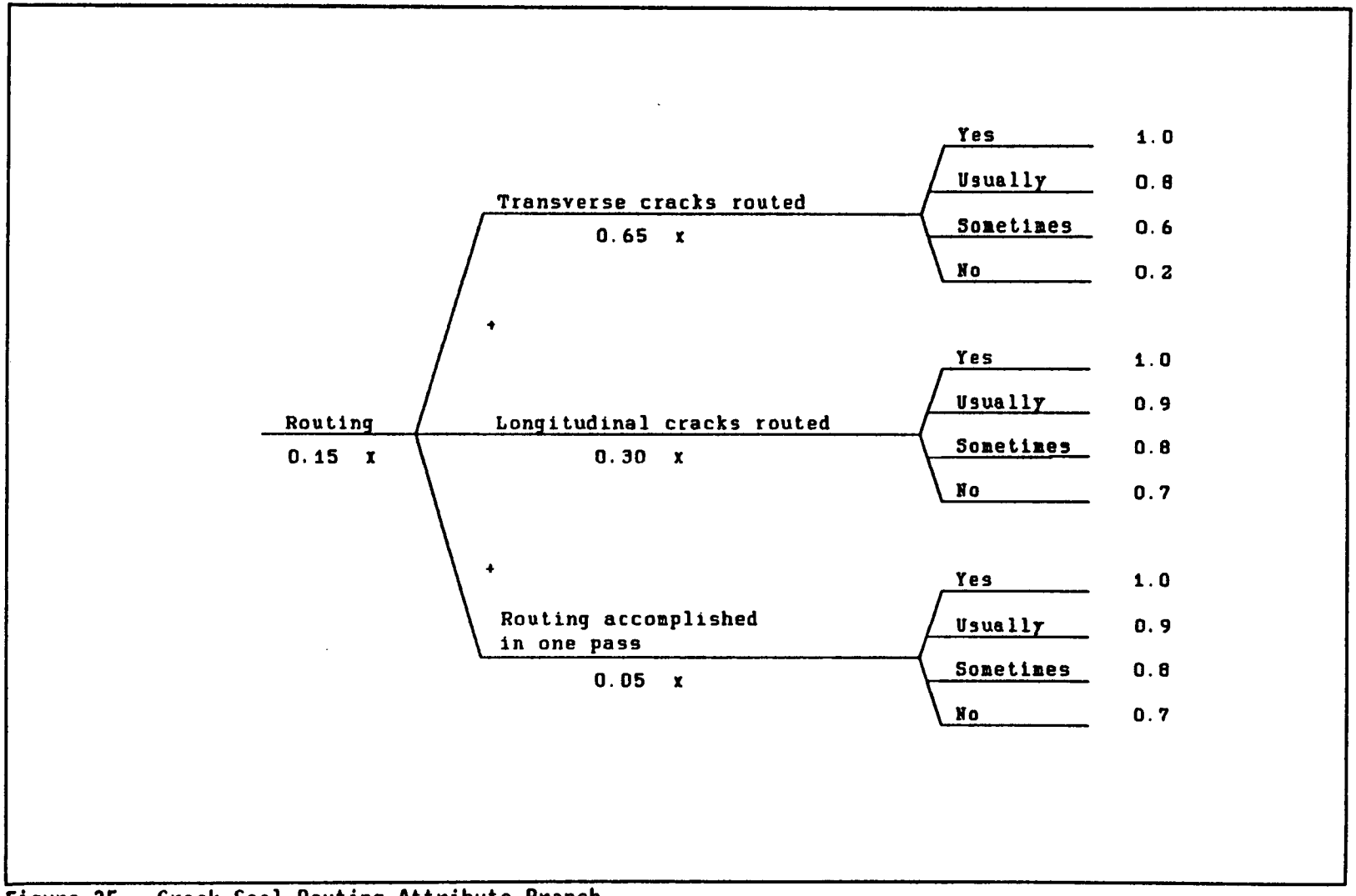


Figure 35. Crack Seal Routing Attribute Branch

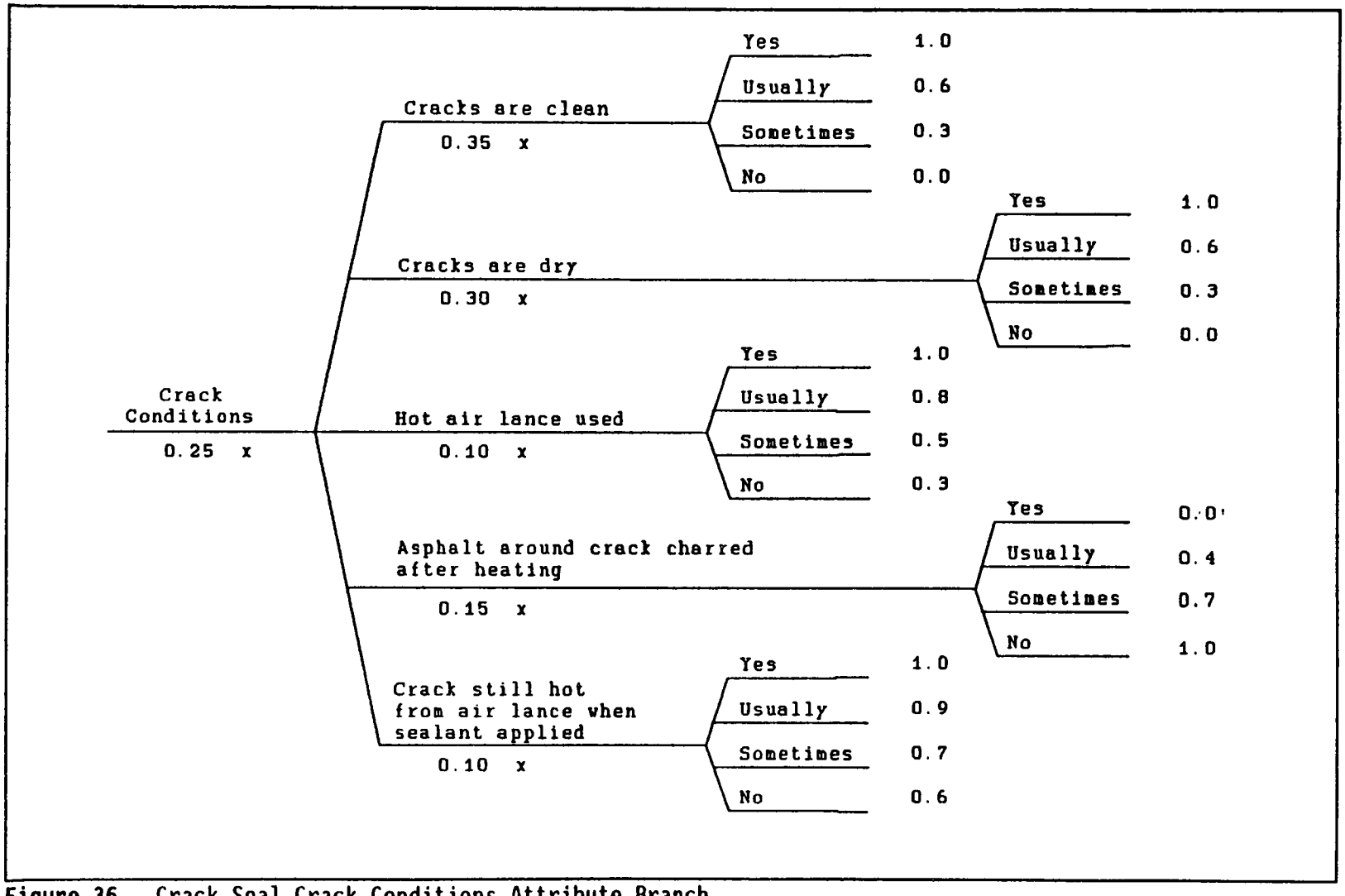


Figure 36. Crack Seal Crack Conditions Attribute Branch

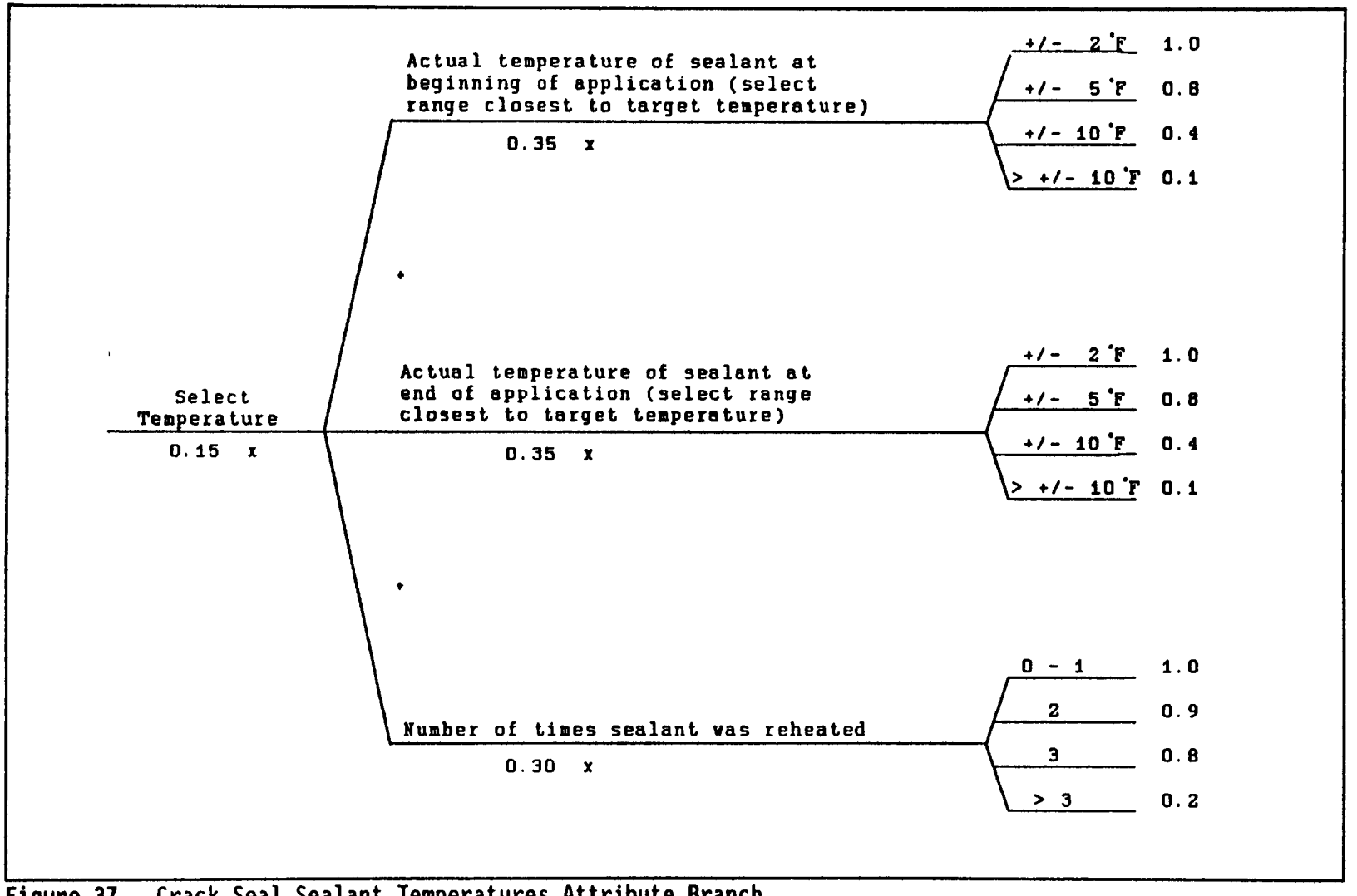


**Figure 37.** Crack Seal Sealant Temperatures Attribute Branch

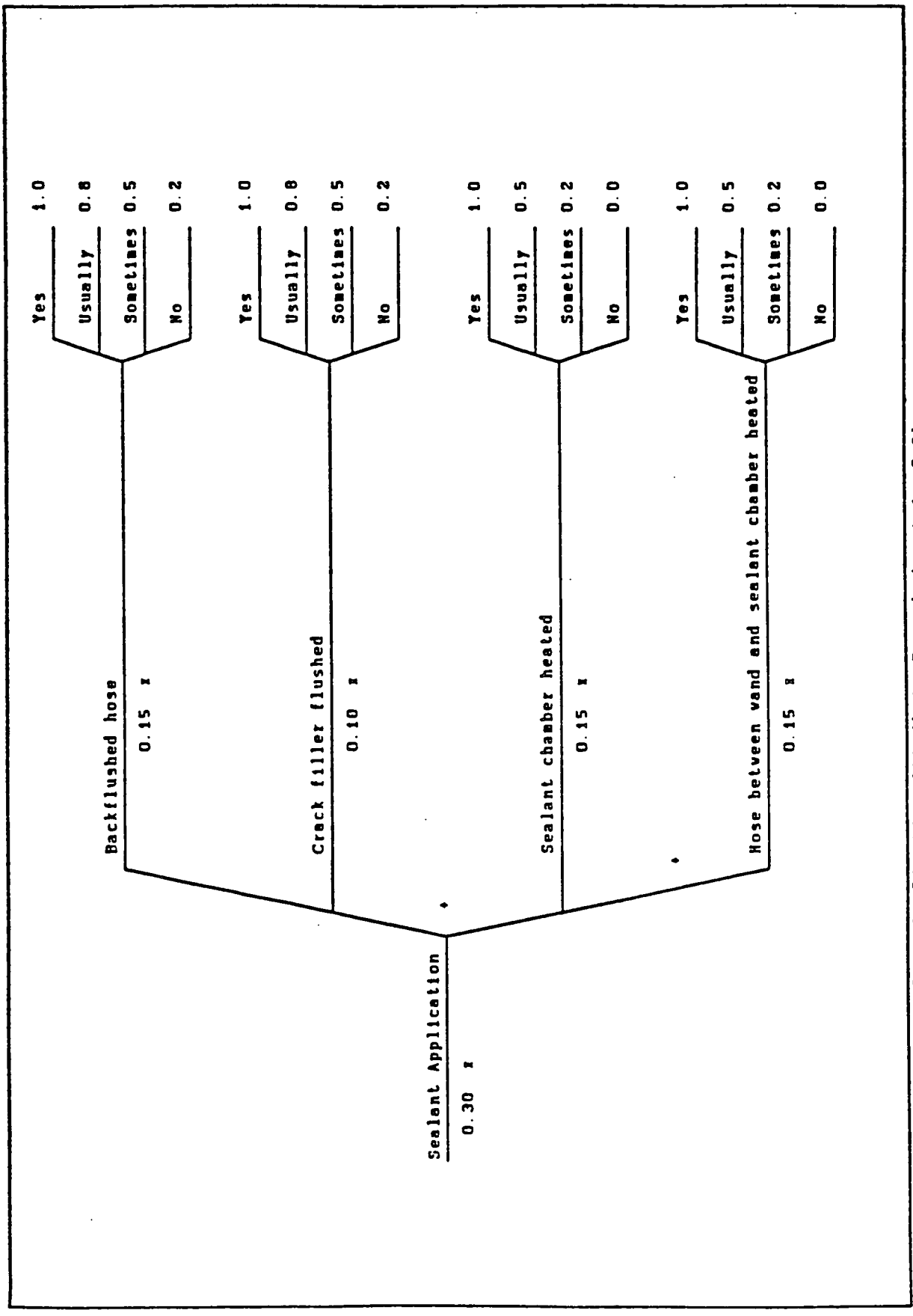


Figure 38. Crack Seal Sealant Application Attribute Branch (part 1 of 2)

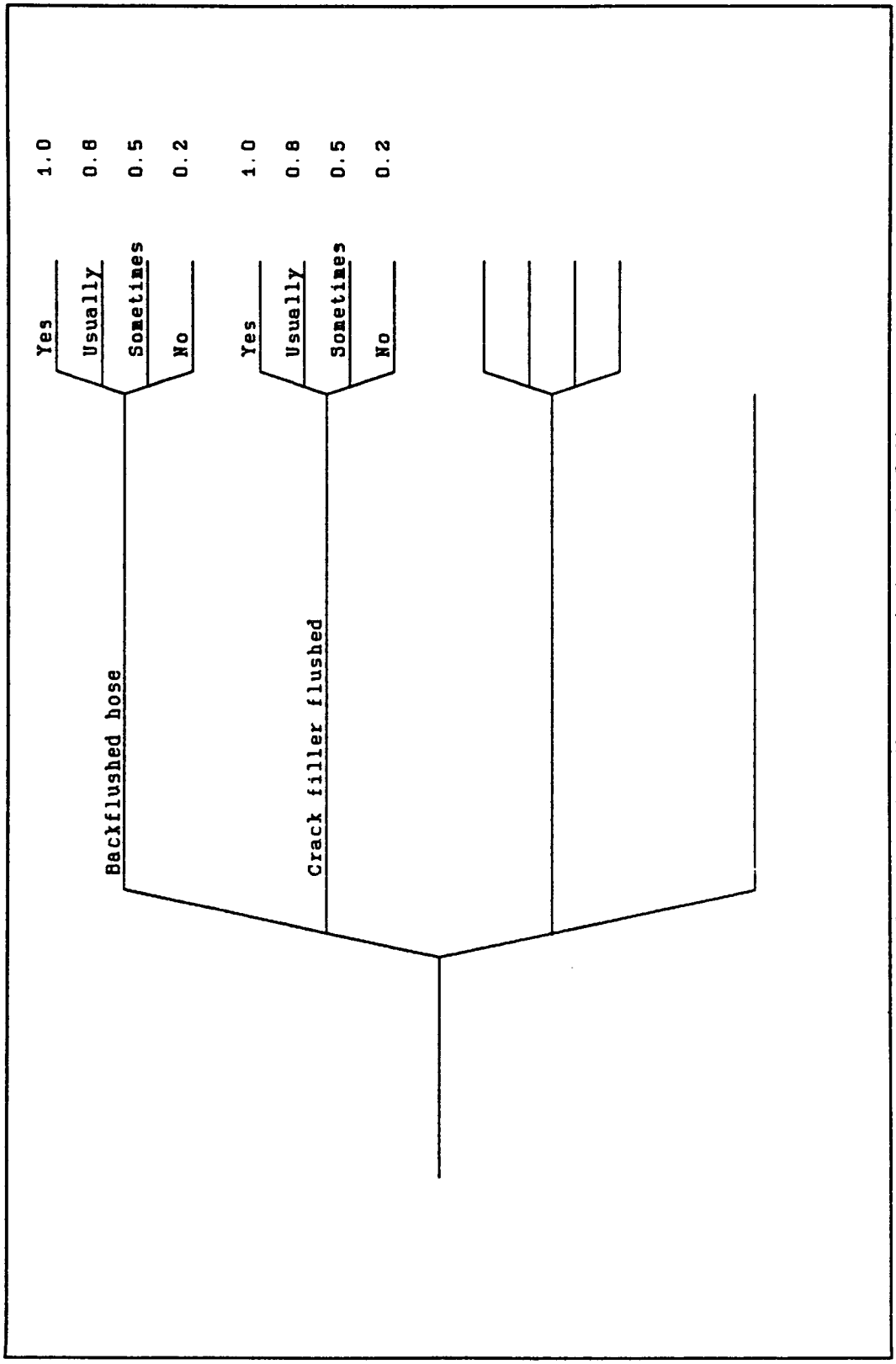


Figure 38. Crack Seal Sealant Application Attribute Branch (part 1 of 2)

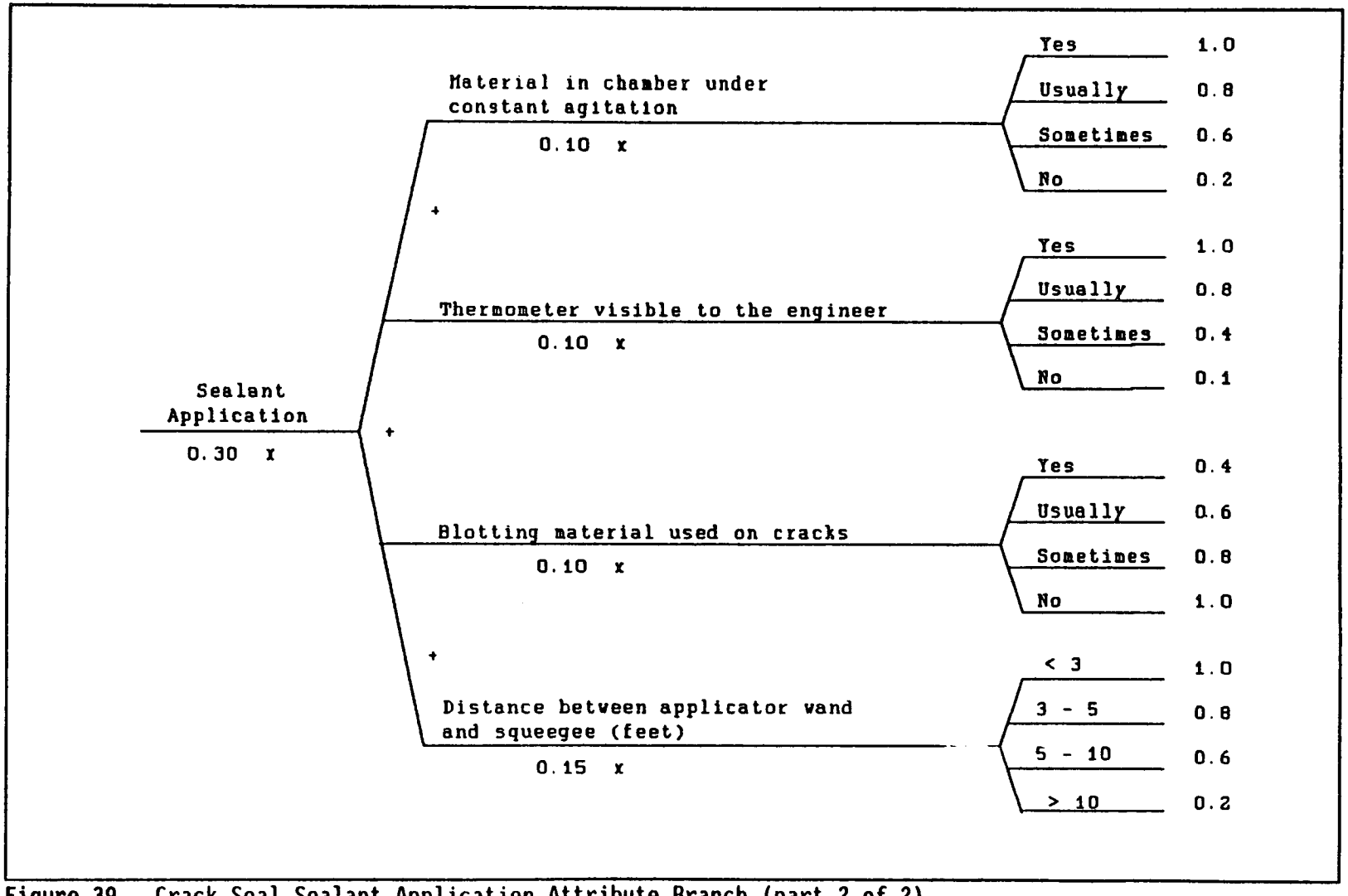


Figure 39. Crack Seal Sealant Application Attribute Branch (part 2 of 2)

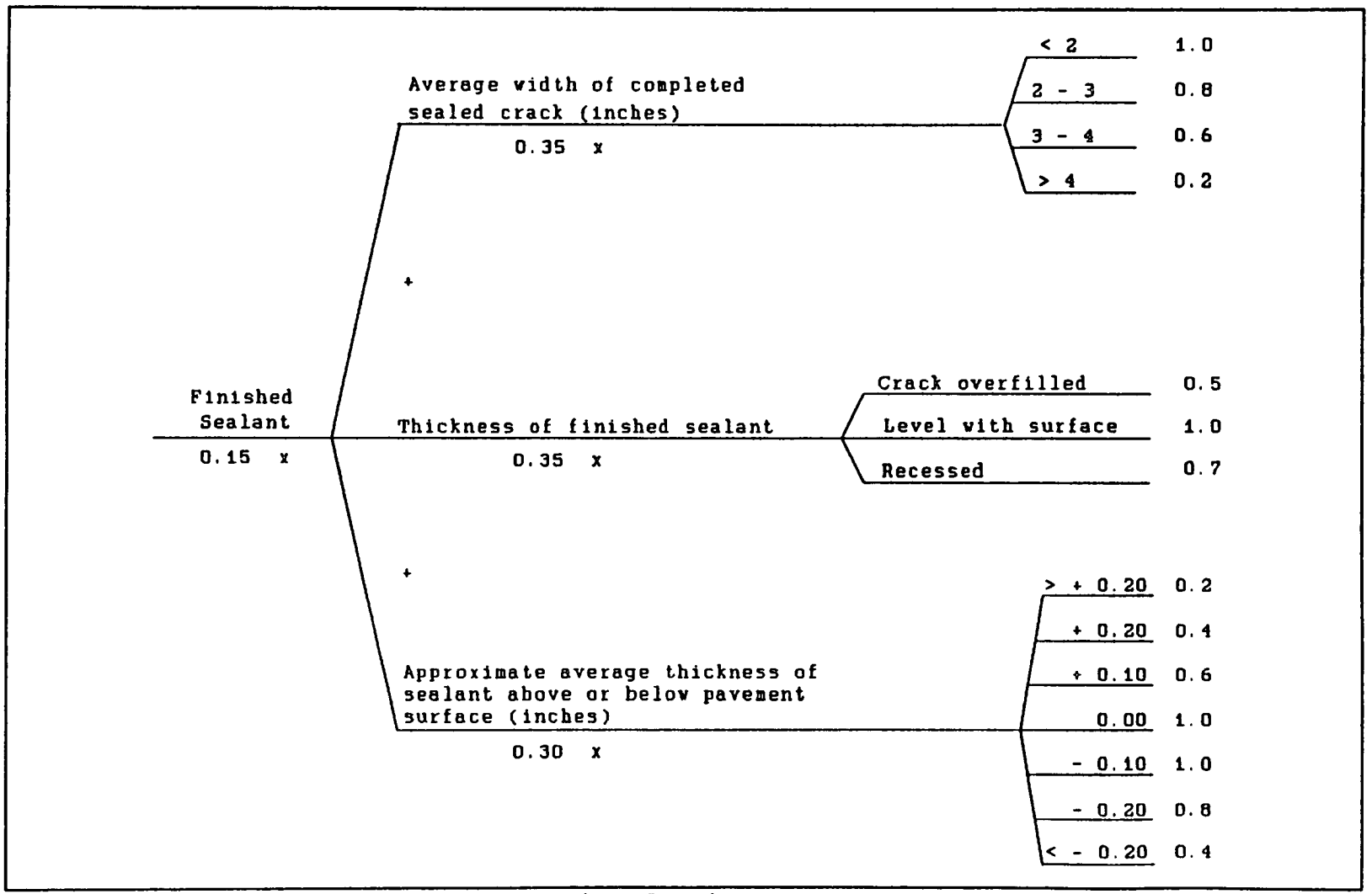


**Figure 40.** Crack Seal Finished Sealant Attribute Branch

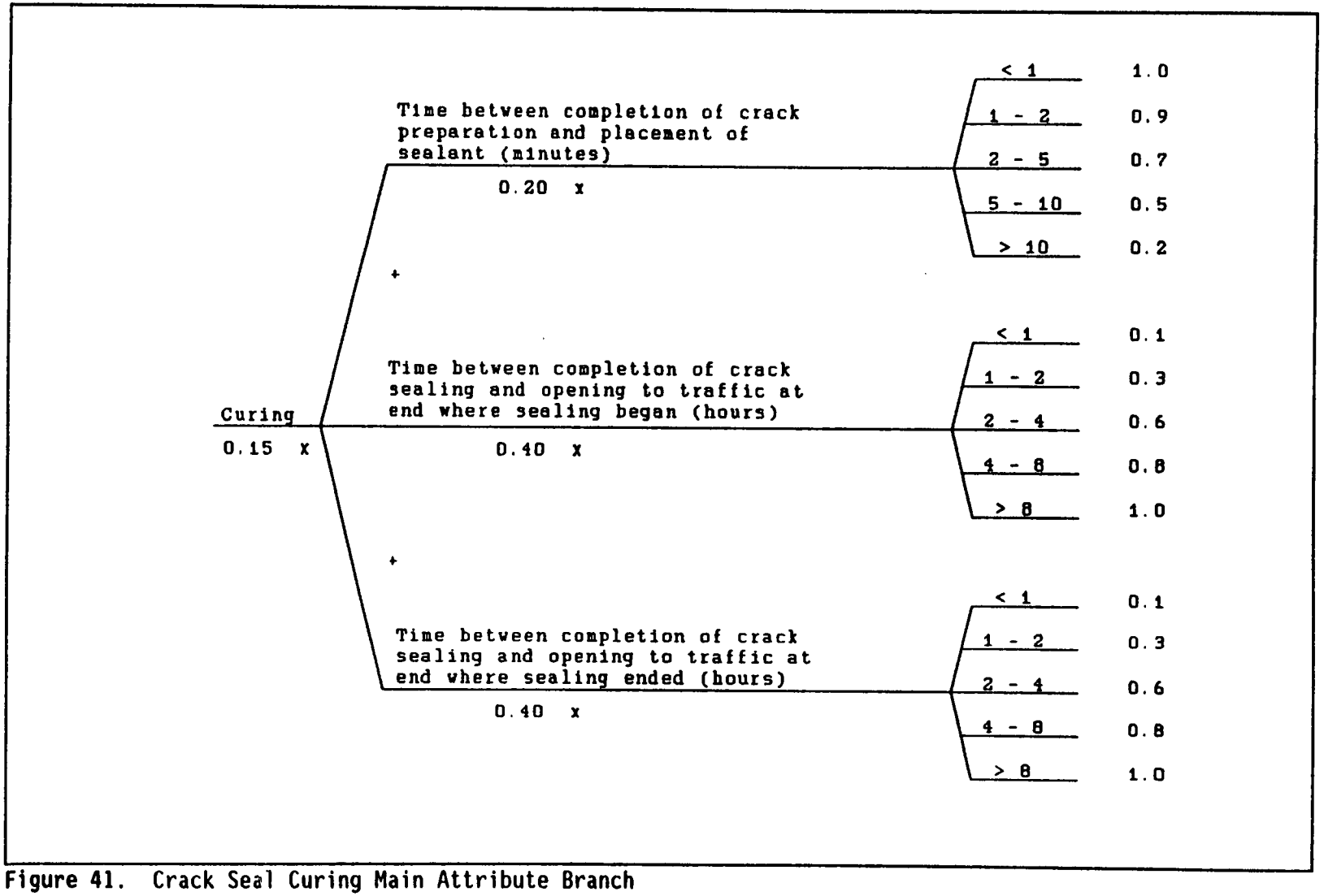


Figure 41. Crack Seal Curing Main Attribute Branch

# Appendix C

## Sample Data Set

| | | |
|---|---|---|
| Sheet 1 | *STATE ASSIGNED ID | [ _ _ _ _ ] |
| SPS-3 DATA | *STATE CODE | [ 4 8] |
| LTPP PROGRAM | *SHRP SECTION ID | [ H 3 5 0] |

## CHIP SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

1. *DATE WORK BEGAN (MONTH/DAY/YEAR) [ 1 0 / 1 1 / 9 0]

   *DATE WORK WAS COMPLETED (MONTH/DAY/YEAR) [ 1 0 / 1 1 / 9 0]

2. *TIME WORK WAS BEGUN (Hr/Min) [ 2 / 2 8]

   *TIME OF DAY (AM = 1, PM = 2) [ 2]

   *TIME WORK WAS COMPLETED (Hr/Min) [ 2/ 4 5]

   *TIME OF DAY (AM = 1, PM = 2) [ 2]

3. *LENGTH OF TEST SECTION SEALED (Feet) [ 7 0 0]

   *WIDTH OF TEST SECTION SEALED (Feet) [ 1 3.1]

4. *TYPE OF SEAL COAT [ 3]
   AGGREGATE SEAL.....3

5. *TYPE/GRADE OF BITUMINOUS MATERIAL IN SEAL COAT
   (SEE TABLE A.16 FOR TYPE CODE) [ 3 0]
   DESCRIPTION OF "OTHER CEMENT" [ ]

   MANUFACTURER NAME [ Ergon Asphalt Vicksburg, MS ]

   MANUFACTURER MATERIAL NAMES [ CRS-2 ]

6. *WAS APPLICATION RATE OF BITUMINOUS MATERIAL ADJUSTED AT JOBSITE TO CORRECT FOR SURFACE CONDITION (YES = 1, NO = 2) [ 1]

7. *TARGET APPLICATION RATE FOR BITUMINOUS MATERIAL (Gallons/Sq. Yd) [ .4 0 0]

8. *ACTUAL APPLICATION RATE FOR BITUMINOUS MATERIAL MEASURED FROM DISTRIBUTOR READINGS (Gallons/Sq. Yd) [ .3 9 3]

9. *ACTUAL APPLICATION RATE FOR BITUMINOUS MATERIAL MEASURED FROM DISTRIBUTOR TANK MEASUREMENTS (Gallons/Sq. Yd) [ .3 8 4]

10. *TARGET APPLICATION TEMPERATURE OF BITUMINOUS MATERIAL (°F) [ 1 5 0]

11. *ACTUAL APPLICATION TEMPERATURE OF BITUMINOUS MATERIAL (°F) [ 1 5 0]

| | | |
|---|---|---|
| Sheet 2 | *STATE ASSIGNED ID | [__ __ __ __ ] |
| SPS-3 DATA | *STATE CODE | [ 4 8] |
| LTPP PROGRAM | *SHRP SECTION ID | [ H 3 5 0] |

## CHIP SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

12. *TYPE OF AGGREGATE USED IN SEAL COAT
(SEE TABLE A.9 FOR TYPE CODE) [ 2 3]

DESCRIPTION OF "OTHER AGGREGATE" [ Crushed River Gravel ]

AGGREGATE SOURCE [ Capitol Aggregates San Antonio, TX ]

13. *TARGET APPLICATION RATE FOR AGGREGATE (Pounds/Sq. Yard) [ 2 2.0]

14. *ACTUAL APPLICATION RATE FOR AGGREGATE IN WHEEL PATHS
(Pounds/Sq. Yard) [ 2 3.0]

15. *ACTUAL APPLICATION RATE FOR AGGREGATE BETWEEN WHEEL PATHS
(Pounds/Sq. Yard) [ 2 2.5]

16. *INITIAL EXISTING PAVEMENT SURFACE PREPARATION (SWEEPING REQUIRED) [ 2]

| | |
|---|---|
| NONE.....1 | COLD MILL.....3 |
| SWEEP CLEAN ONLY.....2 | SHOT BLAST.....4 |
| OTHER (SPECIFY) _____ | 5 |

17. *PAVEMENT CONDITIONS AT TIME SEAL COAT APPLIED
PAVEMENT TEMPERATURE (°F) (60 °F Required) [ 7 9]

CONDITION OF SURFACE BEFORE SEALING [ 1]

| | |
|---|---|
| CLEAN .....1 | MOSTLY CLEAN.....2 |
| SOMEWHAT DIRTY....3 | DIRTY.....4 |

SURFACE MOISTURE CONDITION [ 1]

| | |
|---|---|
| DRY ..... 1 | MOSTLY DRY.....2 |
| SOMEWHAT MOIST.....3 | WET.....4 |

18. *AMBIENT CONDITIONS AT TIME SEAL COAT APPLIED
AIR TEMPERATURE (°F) (60 °F Required) LOW [ 8 2]
HIGH [ 8 3]

RELATIVE HUMIDITY (Percent) [ 5 3]

19. *SURFACE CONDITION [ 2]

| | |
|---|---|
| BADLY OXIDIZED .....1 | NORMAL .....3 |
| SLIGHTLY OXIDIZED.....2 | SLIGHTLY FLUSHED.....4 |
| FLUSHED.....5 | FLUSHED ONLY IN WHEEL PATHS..6 |
| OTHER (SPECIFY) _____ | 7 |

| | | |
|---|---|---|
| Sheet 3 | *STATE ASSIGNED ID | [__ __ __ __ ] |
| SPS-3 DATA | *STATE CODE | [ 4 8] |
| LTPP PROGRAM | *SHRP SECTION ID | [ H 3 5 0] |

CHIP SEAL APPLICATION DATA FOR PAVEMENT WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

20. *AVERAGE CRACK SEVERITY LEVEL (SEE DISTRESS IDENTIFICATION MANUAL)
LOW = 1, MODERATE = 2, HIGH = 3 [ 1]

21. *PRIMARY TYPE OF CRACKS (SEE TABLE A.22 FOR TYPE CODES) [__ 0]
SEE DISTRESS IDENTIFICATION MANUAL FOR DESCRIPTION

22. *ESTIMATED PERCENT OF CRACKS SEALED [__ __ 0]

23. *AGGREGATE CONDITION PRIOR TO USE (CLEAN OR ONLY SLIGHTLY DIRTY REQUIRED)
CLEAN = 1 ONLY SLIGHTLY DIRTY = 2 SOMEWHAT DIRTY = 3 DIRTY = 4 [ 2]

VERY DRY.....1 DRY..... 2 ONLY SLIGHTLY DAMP..3
SOMEWHAT DAMP..... 4 SLIGHTLY WET.. 5 WET..... 6 [ 6]

24. *AGGREGATE MOISTURE CONTENT (PERCENT BY WEIGHT) [__ 1.5]

25. *ESTIMATED TIME BETWEEN APPLICATION OF BITUMINOUS MATERIAL AND SPREADING OF AGGREGATE MATERIAL (SECONDS) [__ 1 5]

26. *ESTIMATED TIME BETWEEN APPLICATION OF AGGREGATE MATERIAL AND INITIAL ROLLING (SECONDS) [__ 2 0]

27. *NUMBER OF COVERAGES PER ROLLER (THREE REQUIRED) [ 5]

28. *TRAFFIC KEPT OFF OF SURFACE UNTIL ROLLING COMPLETED
(YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4) [ 1]

29. *ESTIMATED TIME REQUIRED TO COMPLETE ROLLING AFTER AGGREGATE IS SPREAD (Minutes) [ 1 8.0]

30. *ESTIMATED TIME BETWEEN FINAL ROLLING AND BROOMING SECTION (HOURS) [__ 2.3]

31. *ESTIMATED TIME BETWEEN FINAL ROLLING AND OPENING SECTION TO REDUCED SPEED TRAFFIC (HOURS) [__ 2.8]

32. *MAXIMUM REDUCED SPEED ALLOWED (MPH) [ 3 0]

33. *ESTIMATED TIME BETWEEN FINAL ROLLING AND OPENING SECTION TO FULL SPEED TRAFFIC (HOURS) [__ 2.8]

34. *METHOD USED TO CONTROL TRAFFIC SPEED (PILOT VEHICLES = 1, FLAGMEN = 2, SIGNS = 3, NONE = 4) [ 2]

Sheet 4 *STATE ASSIGNED ID [ ]

SPS-3 DATA *STATE CODE [4 8]

LTPP PROGRAM *SHRP SECTION ID [H 3 5 0]

## EQUIPMENT USED IN CHIP SEAL APPLICATION

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

**35. *ROLLER DATA**

| ROLLER BRAND AND NUMBER | ROLLER DESCRIPTION | GROSS WT. (TONS) | TIRE PRES (PSI) | WIDTH (INCHES) | SPEED (MPH) |
|---|---|---|---|---|---|
| Cat., 9 wheel, PS-130 | Pneumatic-tired | 3.3 | 55. | 69. | 4.0 |
| Cat.,11 wheel, PS-130 | Pneumatic-tired | 3.4 | 52. | 85. | 4.0 |
| | Pneumatic-tired | .. | ... | .. | .. |
| | Pneumatic-tired | .. | ... | .. | .. |

**36. *ROLLING INFORMATION** (YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)

ROLLER SPEED EXCEEDS 5 MPH [4]

FINAL ROLLER COVERAGES IN DIRECTION OF TRAFFIC [3]

ROLLERS OPERATE IN A LONGITUDINAL FORWARD DIRECTION [1]

**37. *DISTRIBUTOR**

BRAND Etnyre Black Topper

MODEL BT-RS

YEAR [1978]

NOZZLE ANGLE (Degrees) [30]

SPRAY BAR HEIGHT (Inches) [12.0]

NOZZLE SPACING (Inches) [ 4.0]

NOZZLE BRAND Etnyre

MODEL 3/16"

**38. *DISTRIBUTOR DETAILS** (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4)

CLEANED BEFORE USE [1]

EQUIPPED WITH A BITUMETER THAT REGISTERS IN FT/MIN OR GAL/SY [1]

BITUMETER VISIBLE TO OPERATOR [1]

BITUMETER USED BY OPERATOR [1]

EQUIPPED WITH A TACHOMETER ON THE PUMP [1]

TACHOMETER VISIBLE TO THE OPERATOR [1]

TACHOMETER USED BY OPERATOR [1]

EQUIPPED WITH HEATERS THAT CAN BE USED TO BRING THE EMULSIFIED ASPHALT MATERIAL TO SPRAY APPLICATION TEMPERATURE [1]

THERMOMETER VISIBLE TO OPERATOR [4]

THERMOMETER WELL FREE OF CONTACT WITH THE HEATING TUBE? [1]

EQUIPPED WITH A FULL CIRCULATORY SYSTEM INCLUDING THE SPRAY BAR [1]

Sheet 5 *STATE ASSIGNED ID [__ __ __ __ ]

SPS-3 DATA *STATE CODE [_4 _8]

LTPP PROGRAM *SHRP SECTION ID [_H _3 _5 _0]

## EQUIPMENT USED IN CHIP SEAL APPLICATION (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

39. *DOUBLE OR TRIPLE LAP (DOUBLE = 1, TRIPLE = 2) [_1]

40. *APPLICATION OF ASPHALT (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4, NA = 5)
    - WAS UNIFORM SPRAY APPLIED [_1]
    - WAS ATOMIZATION NOTICED [_4]
    - WERE ANY LOCATIONS MISSED OR DEFICIENT IN ASPHALT [_4]
    - WAS A HANDSPRAYER USED TO TOUCH UP MISSED SPOTS [_5]
    - WAS BUILDING PAPER USED AT THE BEGINNING OF THE TREATMENT [_1]
    - WAS BUILDING PAPER USED AT THE END OF THE TREATMENT [_1]
    - WAS STREAKING OF THE ASPHALT NOTICED [_4]
    - WERE END NOZZLES USED TO ALLOW FOR AN OVERLAP OF EMULSIFIED ASPHALT BINDER TO THE ADJACENT LANE [_1]

41. *AGGREGATE SPREADER
    - BRAND Etnyre
    - MODEL Not Available

42. *IS A SELF-PROPELLED MECHANICAL SPREADER USED ? (YES = 1, NO = 2) [_1]

43. *SPREADING OF AGGREGATE (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4, NA = 5)
    - IS AGGREGATE SPREAD UNIFORMLY [_1]
    - IS STREAKING OF THE AGGREGATE NOTICED [_4]

44. *IS A MOTORIZED POWER BROOM USED TO REMOVE LOOSE MATERIAL FROM THE SURFACE AFTER ROLLING IS COMPLETE? (YES = 1, NO = 2) [_1]

45. *NUMBER OF PASSES WITH BROOM [__ _1]

46. *ESTIMATED PERCENT OF LOOSE MATERIAL REMOVED DURING BROOMING [_3]
    - NONE (<1%).....1
    - VERY LITTLE (1 - 3%).....2
    - SOME (3 - 5%).....3
    - SUBSTANTIAL (>5%).....4

47. *ESTIMATED PERCENT OF LOOSE MATERIAL REMAINING AFTER BROOMING [_2]
    - NONE (<1%).....1
    - VERY LITTLE (1 - 3%).....2
    - SOME (3 - 5%).....3
    - SUBSTANTIAL (>5%).....4

# Appendix D

## SPS-3 Specifications

## North Central Region

**Illinois**
**Indiana**
**Iowa**
**Kansas**
**Kentucky**
**Manitoba**
**Michigan**
**Minnesota**
**Missouri**
**Nebraska**
**Saskatchewan**

## SPECIAL CONTRACT REQUIREMENTS

The following Special Contract Requirements amend and supplement the Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-85, U.S. Department of Transportation, Federal Highway Administration.

### Section 101.--DEFINITIONS AND TERMS

**101.01 Abbreviations.** Add the following:

**CFLHD** -- Central Federal Lands Highway Division

**SHRP** -- Strategic Highway Research Program

**DFT** -- Direct Federal Test

**101.02 Definitions.** Amend as follows:

**Government.** Add the following:

The term "Government" when used in connection with sampling, testing, and traffic control shall also include Province/State Highway and SHRP representatives.

## Section 102.--BIDDING REQUIREMENTS AND CONDITIONS

102.01 Bidder Qualification. Add the following:

The two-step sealed bidding process being used for this solicitation requires that bidders submit an acceptable technical proposal for completing the work before they are allowed to submit sealed bid prices. Award of the contract is then made to the responsible bidder whose bid, conforming to the solicitation and their technical proposal, will be most advantageous to the Government considering only price and price related factors. Bidders will be considered responsible if they meet the following Standards of Responsibility:

(a) General Standards. To be determined responsible, a bidder must--

(1) have adequate financial resources to perform the contract, or the ability to obtain them;

(2) be able to comply with the required or proposed delivery or performance schedule, taking into consideration all existing commercial and governmental business commitments;

(3) have a satisfactory performance record;

(4) have a satisfactory record of integrity and business ethics;

(5) have the necessary organization, experience, accounting and operational controls, and technical skills, or the ability to obtain them (including, as appropriate, such elements as production control procedures, property control system, and quality assurance measures applicable to materials to be produced or services to be performed by the prospective contractor and subcontractors);

(6) have the necessary production, construction, and technical equipment and facilities, or the ability to obtain them; and

(7) be otherwise qualified and eligible to receive an award under applicable laws and regulations.

(b) Special Standards. To be determined responsible, a bidder must have successfully completed at least five highway construction projects during the past 7 years which total at least 50 lane miles of either chip sealing or slurry sealing.

Bidders shall submit with their technical proposal a list of successfully completed projects for use by the Government in determining if the low bidder is responsible. The list shall include name and location of project, contracting authority or owner, contact person with telephone number, cost of project, and cost of chip sealing or slurry sealing work.

## Section 104.--SCOPE OF WORK

104.01 Intent of Contract. Delete the text of this subsection and substitute the following:

The intent of the contract is to provide for the construction of the maintenance test sections described in this contract. The Contractor shall furnish all labor, materials, equipment, tools, transportation, and supplies required to complete the work in accordance with the plans, specifications, and terms of the contract. The work on each specific type of roadway treatment on all of the project sites shall be constructed and completed with the same supervision, same key personnel, and same equipment. Each material type used in the work shall be furnished from a single source as provided in Subsection 106.01.

Surface preparation prior to surface treatment application will be accomplished by Province/State forces.

104.02 Changes, Differing Site Conditions, and Variations in Estimated Quantities.

(a) Add the following:

In the event it is necessary to delete a site and add a replacement site, Pay Item 104(1), Relocation Mileage will be used to compensate the Contractor for any and all costs associated with a location change of 20 miles or more. Any change in site location of less than 20 miles will not be measured or paid for but will be considered inherent to the nature of the work. Any change of 20 miles or more will be paid for regardless of when notification of the change is given to the contractor, or the degree of impact the change may have on their operations.

### Method of Measurement

104.02A (Added subsection.) Relocation mileage will be measured by the shortest practical route utilizing major highways for any change in location of 20 miles or more from the site shown on the plans to the new site location designated by the Engineer.

### Basis of Payment

104.02B (Added subsection.) The quantity, determined as provided above will be paid for at the contract price per unit of measurement for the pay item listed below and shown in the bid schedule, which price and payment will be full compensation for the work prescribed in this section.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 104(1) Relocation Mileage | Mile |

104.03 Disputes. Add the following:

(a) The supplement to Contract Clause 52.233-1, Disputes, as provided in paragraph (b) below is only applicable when the Contractor requests a formal Contracting Officer's decision. "Formal Contracting Officer's decision," as used in this subsection, means one which the Contractor requests under Contract Clause 52.233-1 and may carry to appeal as provided for in the Contracts Disputes Act of 1978 if the decision does not resolve the dispute to the Contractor's satisfaction.

(b) Contract Clause 52.233-1 is supplemented as follows:

When requesting a Contracting Officer's decision for an interpretation of contract terms where the recovery of increased costs is the essence of the request, the Contractor must quantify the amount and, if in excess of $50,000, must certify the amount in accordance with Contract Clause 52.233-1. The request must include an explanation of the basis of the Contractor's interpretation, any supporting documentation, and adequate cost data to support the amount claimed.

104.06 Maintenance for Traffic During Suspension of Work. Delete the text of this subsection and substitute the following:

The Government will provide for maintaining traffic over the project during periods of standby, partial work suspension, or during periods of total suspension.

Prior to any suspension of work or being placed on standby as provided in Subsection 108.06A, the Contractor shall remove equipment from the project site and return the roadway surface to a condition which will accommodate traffic and can be maintained by routine Province/State maintenance.

Additional work required to restore the work sites after periods of suspension or standby and considered beyond the control of the Contractor will be paid for in accordance with Subsection 109.07 or Subsection 109.08.

104.08 Availability of Contractor Records. (Added subsection.)

Upon request by the Contracting Officer, Contractor records related to this contract shall be made available in a timely manner to the Contracting Officer: (a) during contract performance; (b) for 3 years after final payment; and (c) for such longer period, if any, as is required by applicable statute or by any other contract clause.

All subcontracts at any tier shall include a provision giving the Government the same rights as provided above with respect to the subcontractor's records.

## Section 105.--CONTROL OF WORK

105.06 Layout of Work. Add the following:

The layout and location of each project site has been determined and marked in the field. Plan Sheet No. 15 shows the general layout of a typical project site. The exact order of each individual treatment area and the distance between them may vary from project site to project site.

Each treatment will cover two lanes of traffic. As shown on Plan Sheet No. 15, the typical treatment area is 700 foot long. The lane which does not contain the test section shall be done first to allow identification of adjustments needed to the operation. The lane containing the test section shall be done last. The chip and slurry seal treatments in each lane shall be done in the direction of travel.

105.09 Inspection of Work by Others. Delete the text of this subsection and substitute the following:

Due to the research to be performed as a result of this project and the number of agency and research groups involved, there may be a large number of people at the work sites. A substantial amount of information will be gathered before, during, and after the construction of each individual treatment area. An example of the types of information to be gathered by the Strategic Highway Research Program (SHRP) inspectors or their representative during construction is included in Section J, "Checklists." The Contractor shall cooperate with the SHRP and Province/State Highway representatives and adapt scheduling and performance of work under this contract to accommodate the gathering of this information during construction.

Such inspection, sampling, testing, and gathering of information will in no sense make these agencies or research groups a party to the contract. The Project Engineer as the Contracting Officer's Representative will be responsible for administering the project.

105.11 Maintenance of the Work During Construction. Delete the text of this subsection.

105.12 Acceptance. Delete the text following paragraph (a), Partial Acceptance, and substitute the following:

When the Contractor has completed a project site in compliance with the contract, that unit will be accepted and the Contractor will be relieved of further responsibility for that unit. Such partial acceptance shall in no way void or alter any of the terms of the contract.

## Section 106.--CONTROL OF MATERIAL

106.01 Source of Supply and Quality Requirements. Add the following:

All materials used in the work shall be furnished from sources selected by the Contractor and approved by the Engineer. However, each material for each type of treatment shall be provided from one, and only one, source. Materials for each type of treatment are listed below:

- o Aggregate for chip seal treatment.
- o Asphalt emulsion for chip seal treatment.
- o Aggregate and mineral filler for conventional slurry seal treatment.
- o Asphalt emulsion for slurry seal treatment.
- o Crack sealant for crack sealing.

NOTE: Asphalt emulsion for all chip seal treatment shall be produced using the same base asphalt cement, same emulsifying agent, same additives if required, and the same production equipment.

Asphalt emulsion for all slurry seal treatment shall be produced using the same base asphalt cement, same emulsifying agent, same additives if required, and the same production equipment.

106.04 Contractor Inspection System. Delete the text of this subsection and substitute the following:

See FAR Clause 52.246-12.

106.05 Statistical Evaluation of Materials for Acceptance. Delete the text and tables of this subsection.

106.06 Government Acceptance Sampling and Testing. Delete the text of this subsection and substitute the following:

(a) Aggregates. The Engineer will perform acceptance sampling, testing, and inspection to determine the acceptability of materials and work. Acceptance of material will be based on test results from acceptance samples taken by the Engineer and tested by the Government.

(b) Asphalt, Crack Sealant, and Mineral Filler. Prior to use, samples of all material proposed for use shall be submitted to the Engineer. The Engineer shall be afforded the opportunity to witness all sampling.

(c) Acceptance. The acceptance of materials is outlined below:

(1) Aggregates. The aggregate material shall meet the requirements in Subsection 703.13 for grading and quality during manufacture and placement into temporary stockpiles, at or near the point of production, and when placed in hauling vehicles for delivery to the project sites. The aggregates will be sampled by the Government at the

stockpile for acceptance. Sampling of aggregates shall be in accordance with the latest revision of AASHTO Designation T 2 or ASTM Designation D 75. Contamination or degradation of aggregates received at the project sites will be cause for their rejection. When aggregates are rejected for reasons that are considered to be due to improper handling or negligence by the contractor they shall be replaced at no cost to the Government.

(2) Asphalt. Asphaltic materials shall meet the requirements for the grades specified. The asphaltic materials will be accepted by Certification of Compliance as provided in Subsection 702.04.

(3) Crack Sealant. Crack sealant materials shall meet the requirements of Subsection 702.03(c). Crack sealant material will be accepted by manufacturer's Certification of Compliance in accordance with the requirements of Subsection 106.07.

The following shall be provided to the Engineer 5 days prior incorporating the crack sealant material into the work:

- Certificate of Compliance.
- Test reports.
- Manufacturer's application recommendations.
- Recommended heating time and temperature.
- Allowable storage time and temperature after initial heating.
- Allowable reheating criteria.
- Application temperature range.

(4) Water. Water used in the slurry seal and chip seal shall meet the requirements of Subsections 407.05 and 408.06.

(5) Mineral Filler. If required, mineral filler shall meet the requirement for the type determined for the slurry seal mixture. See requirements of Subsection 408.07. Mineral filler material will be accepted by manufacturer's Certification of Compliance in accordance with the requirements of Subsection 106.07. Mineral filler material delivered to the work shall be accompanied by Certificate of Compliance and supported by tests performed by the manufacturer. Copies of such tests shall be furnished to the Engineer.

(d) Additional Sampling. In addition to the sampling listed above, additional informational sampling of the aggregates, mineral filler, asphaltic materials, sealant material, and water may be performed by the Engineer at the project sites.

Section 107.--LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.01 Laws to be Observed. Amend as follows:

Add the following to the first paragraph:

It is the contractors responsibility to familiarize themselves with the applicable work permits, registration fees and tariffs associated with working in the Canadian Provinces of Saskatchewan and Manitoba. In particular, your attention is directed to Saskatchewan's Provincial Education and Health Tax.

Information regarding laws, ordinances, safety codes, regulations, orders, or decrees may be obtained from the following:

Stan Hilderman
Manitoba Highways & Transp.
1181 Portage Ave. (Annex)
Winnipeg, Manitoba R3G 0T3
Canada
204-945-8982
FAX 204-945-2229

Barry D. Martin
Director/Maintenance
Sask. Highways & Transp.
1855 Victoria Ave.
Regina,Saskatchewan S4P 3V5
Canada
306-787-4859
FAX 306-787-1007

Billy Wade
Highway Liaison Engineer
Illinois DOT
2300 South Dirkson Parkway
Springfield, IL 62764
217-782-2984
FAX 217-782-1927

Gary Niemi
District Maint. Engineer
MN/DOT-District 3
301 Laurel St. Box 978
Brainerd, MN 56401
218-828-2468
FAX 218-828-2210

Dwight M. Rorholm, P.E.
Maintenance Opr. Engr.
Iowa DOT
800 Lincoln Way
Ames, IA 50010
515-239-1589
FAX 515-232-0843

Gene Myers
Materials & Research Director
MO Highway & Transp. Dept.
PO Box 270
Jefferson City, MO 65102
314-751-1040
FAX 314-751-8682

Ronald E. Shuberg
Bureau of Const./Maint.
Docking State Office Building
Topeka, KS 66612
913-296-3576
FAX 913-296-6944

Laird E. Weishahn
Nebraska Dept. of Roads
PO Box 94759
Lincoln, NE 68509-4759
402-479-4675
FAX 402-479-4325

William R. Monhollon
Chief District Engineer
KY Transportation Cabinet
977 Phillips Lane PO Box 37090
Louisville, KY 40233
502-367-6411
FAX 502-363-6170

Keith J. Kercher
Manager Pavement Research Section
Division of Research
1250 Montgomery St. PO Box 2279
West Lafayette, IN 47906
317-463-1521
FAX 317-497-1665

Paul F. Miller
Maintenance Division
Michigan DOT
3222 South Logan St.
Lansing, MI 48910
517-394-8659
FAX 517-394-8644

Add the following:

The Secretary of Labor or any authorized representative shall have a right of entry to any site of contract performance for the purpose of making unannounced inspections of the Contractor's activities to determine compliance with OSHA standards (29 CFR 1926).

**107.02 Permits and Responsibilities.** Add the following:

Information regarding permits and responsibilities may be obtained from the representatives listed in Subsection 107.01 above.

**107.10 Responsibility for Damage Claims.** Delete the text of this subsection and substitute the following:

The Contractor shall indemnify and save harmless the Government and each province/state in which work is to be performed, their officers, and employees from all suits, actions, or claims brought for injuries or damage received or sustained by any person, persons, or property resulting from the Contractor's operations or arising out of the negligent performance of the contract. Until the Engineer determines that satisfactory evidence has been provided that the Contractor, and subcontractors when applicable, are protected by the insurance specified below, the Government may retain from the Contractor such sums of money deemed necessary to protect the public interest. Insurance coverage in the minimum amounts set forth herein shall not be construed to relieve the Contractor of liability in excess of such coverage.

(a) Worker's Compensation Insurance. The Contractor shall furnish evidence to the Government that all operations to be performed under the contract are covered by Worker's Compensation Insurance or that this liability is otherwise provided for in accordance with applicable Province/State laws.

(b) Contractor's Bodily Injury and Property Damage Liability Insurance. The Contractor shall procure and maintain at the Contractor's own expense, until final acceptance of the work covered by the contract, insurance in the kinds and amounts specified herein with insurance companies authorized to do business in the applicable Province/State covering all operations under the contract.

Before commencing the work, the Contractor shall furnish certificate of insurance in a form satisfactory to the Engineer showing compliance with this subsection and which certifies that the policies will not be changed or cancelled until 30 days written notice has been furnished the Engineer.

The Contractor shall maintain both Bodily Injury Liability Insurance and Property Damage Liability Insurance. The following minimum coverage shall be provided:

- Bodily Injury Liability Insurance shall provide a limit of not less than $1,000,000 for all damages arising out of bodily injuries to or death of one person; and subject to that limit for each person, a total limit of $2,000,000 for all damages arising out of bodily injuries to or death of two or more persons in any one accident.

- Property Damage Liability Insurance shall provide a limit of not less than $1,000,000 for all damages arising out of injury to or destruction of property in any one accident; and subject to that limit per accident, a total or aggregate limit of $2,000,000 for all damages arising out of injury to or destruction of property during the policy period.

Policy requirements shall be such that insurance provided in compliance with Contractor's Bodily Injury and Property Damage Liability Insurance shall cover liability of the Contractor for damage because of bodily injury to or death of persons and injury to or destruction of property which may be suffered by persons other than the Contractor's own employees as a result of the negligence of the Contractor in performing the work covered by the contract. Policy requirements shall also be such that insurance provided in compliance with Contractor's Property Damage Liability Insurance shall include liability of the Contractor for damage to or destruction of property which may be suffered by persons other than the Contractor's own employees as a result of the negligence of the Contractor in performing the work covered by the contract. Policy requirements shall also be such that insurance provided in compliance with Contractor's Property Damage Liability Insurance shall include liability of the Contractor for damage to or destruction of property which may be suffered by persons other than the Contractor's own employees as a result of blasting operations of the Contractor in performing the work covered by the contract.

(c) Insurance for Subcontractors. If any part of the work is sublet, similar insurance shall be provided by or in behalf of the subcontractors to cover their operations.

**107.15 Accident Prevention and Health Standards.** Add the following:

The Engineer shall be furnished a copy of an accident report within 10 days from the date of the accident.

## Section 108.--PROSECUTION AND PROGRESS

**108.01 Subcontracting.** Delete the text of this subsection and substitute the following:

The Contractor shall perform on each project site and with its own organization the chip sealing and/or slurry sealing as provided by Section 407 and Section 408 respectively. The Contractor may subcontract either the chip sealing or the slurry sealing work for all project sites to a fully qualified subcontractor. To be considered fully qualified, the subcontractor shall meet the standards listed in Subsection 102.01. All other project work may be subcontracted to qualified subcontractors. Subcontracting of work will not relieve the Contractor of liability under the contract and bonds.

No subcontract shall create any contractual relation between subcontractors and the Government. The Contractor shall be liable and responsible for any action or lack of action of a subcontractor. Contractors and subcontractors shall be charged with all direct, imputed, or presumed knowledge the others might possess. As used throughout this contract, a subcontractor shall mean a subcontractor in any tier.

Within 10 days after award of a subcontract for performance of work at the construction site, the Contractor shall deliver to the Engineer completed forms certifying the following:

- The items of work and percentage of the original contract amount to be performed by each subcontractor.
- Evidence that all required contract and labor clauses have been incorporated into and made a part of the subcontract.

The certification shall be on forms furnished by the Government or shall be of a format acceptable to the Engineer. Failure to submit the requested certified information within the time limit specified will be justification for withholding of progress payments.

**108.02 Commencement, Prosecution and Completion.** Add the following:

Unless otherwise authorized by the Engineer, all work at each individual site shall be completed during the same day. The Contractor must complete all three treatments at each project site before proceeding with any work at the next site.

108.03 **Schedules for Construction.** Add the following:

An essential activity of this contract is establishing and maintaining continuous communication with the local Province/State highway agency and Strategic Highway Research Program (SHRP) representatives regarding such items as planning, scheduling, responsibilities, and safety. To assist in the development of this communication network, a preconstruction conference will be arranged by the Government and held in the vicinity of the Contractor's facility. Various Province/State Highway Agencies, SHRP, and Government representatives may attend. The conference shall also be attended by the Contractor's key personnel as defined in Subsection 108.05 below. In addition to discussing the planning, scheduling, and responsibilities of participating parties, SHRP will present a training program on the three types of surface sealing operations.

One of the critical elements of this contract is the maintenance and calibration of equipment. Prior to start of work on the first site, at a time mutually acceptable to the Government and the Contractor, the equipment shall be calibrated in accordance with the following criteria:

| Item | Specifications |
|---|---|
| Chip Sealing | ASTM D2995 |
| Slurry Sealing | International Slurry Seal Association Performance Guidelines A105 |

The calibration site will be selected by the Government at a location near the Contractors facility or elsewhere mutually acceptable to both parties. Calibration will be accomplished using mix designs and materials approved for use on the project.

In conjunction with the calibration, the Contractor shall demonstrate the crack sealing equipment using the sealant approved for use on the project.

No direct payment will be made for the work described above. It will be considered subsidiary to other items of work in the contract. Materials used for calibration purposes and the crack sealing demonstration will be paid for in accordance with the bid items included in the contract.

108.04 **Limitations of Operations.** Add the following:

See Subsection 635.04, Limitations on Construction Operations.

108.05 Character of Workers: Methods and Equipment. Add the following:

Due to the research nature of this work, the same primary equipment and key personnel shall be required to perform the work at all sites in this contract. Key personnel are defined as the person or persons that operate the primary equipment, the Contractor's superintendent, and foreman. The primary equipment is defined below:

| Treatment Type | Primary Equipment |
|---|---|
| Chip Seal | Asphalt distributor,<br>Aggregate spreader, and<br>Rollers. |
| Slurry Seal | Slurry seal mixer, and<br>Spreading equipment. |
| Crack Sealing | Router,<br>Hot-compressed air-lance,<br>Applicator wand, and<br>Sealant heating equipment. |

A list of primary equipment and key personnel as furnished in the technical proposal shall be furnished to the Engineer prior to the preconstruction conference. All requests for substitution and or change of individual pieces of equipment or personnel must be made in writing to the Engineer and no substitution will be allowed unless approved by the Engineer.

108.06A Standby. (Added subsection.)

(a) Description. Due to the experimental nature of the work, the Engineer may suspend work due to adverse weather or other reasons beyond the Contractor's control. When the performance of the work is suspended by order of the Engineer and the Contractor is not able to complete all work at each project site that day, the Contractor will receive Standby. The following will not be considered reasons for suspension of work and will not be eligible for Standby:

(1) Contractor caused delays.
(2) Delays due to waiting for treated surfaces to become stable enough to support traffic.
(3) Delays due to shifting traffic control during the normal course of work.

(b) Measurement. Standby will be measured by the day for each day the work is ordered suspended and the Contractor is not able to complete all work at each project site.

(c) Payment. The quantity as determined above will be paid for at the contract unit price listed below. Payment will be full compensation for all costs and overhead expenses incurred by the Contractor, subcontractor(s), and supplier(s). Standby will not be paid for scheduled travel days, scheduled non-workdays, or non-workdays as specified elsewhere.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 108(1) Standby | Day |

**108.07 Failure to Complete Work within Contract Time.** Delete the text and Table 108-1 of this subsection and substitute the following:

The following supplements Contract Clause 52.212-5. Liquidated damages in the amount set forth in the following table will be charged for each day of delay beyond September 15, 1990, until the work is complete.

Table 108-1
Charge for Liquidated Damages for Each Day of Delay

| Original Contract Price | | Liquidated Damages |
|---|---|---|
| From More Than | To and Including | Per Day of Delay |
| $ 0 | $ 25,000 | $ 75 |
| 25,000 | 50,000 | 125 |
| 50,000 | 100,000 | 250 |
| 100,000 | 500,000 | 500 |
| 500,000 | 1,000,000 | 750 |
| 1,000,000 | 2,000,000 | 1,250 |
| 2,000,000 | 5,000,000 | 1,750 |
| 5,000,000 | 10,000,000 | 2,500 |
| 10,000,000 and more | | 3,000 |

## Section 109.--MEASUREMENT AND PAYMENT

109.03 Weighing Devices and Procedures. Add the following to the eighth paragraph:

Increments smaller than 100 pounds may be read and recorded when an automatic weigh system is used.

109.06A Pricing of Adjustments. (Added subsection.)

The provisions of all clauses of the contract providing for any determination of a contract price adjustment are supplemented as follows:

(a) Upon written request, the Contractor shall submit a proposal in accordance with the requirements and limitations set forth in this subsection for the cost or pricing of the adjustment. The proposal shall be submitted within the time limit indicated in the request or any extension of such time limit as may be subsequently granted. The Contractor's written proposal for any adjustment shall be submitted in the following form:

(1) Proposals totaling $10,000 or less shall be submitted in the form of unit prices for each item of work or a lump sum amount for the total work. If evaluation of the price by the Contracting Officer does not result in acceptance, the Contractor shall resubmit the proposal in accordance with (2) below.

(2) For proposals in excess of $10,000, the submission shall be in the form of unit prices for each item of work or a lump sum amount for the total work. The proposal shall include an itemized breakdown of all increases and decreases in the contract price in at least the following detail:

Direct Costs

- Materials - Provide supplier quotations or paid invoices of previous transactions.
- Labor - Show rates, fringes, etc., for all classifications of workers employed in the performance of the work related to the adjustment. Show a breakdown of payroll burden such as FICA, FUTA, worker's compensation and insurance, etc.
- Equipment rates - Provide a complete descriptive listing of equipment. Rented or leased equipment costs shall be supported by supplier quotations. Allowable ownership and operating costs for Contractor and/or subcontractor owned construction equipment shall be determined as follows:

(i) Actual cost data shall be used when such data can be determined for ownership and/or operating costs for each piece of equipment or groups of similar serial or series equipment from the Contractor's or subcontractor's accounting records.

(ii) When actual costs cannot be determined, the most current Construction Equipment Ownership and Operating Expense Schedules, published by the U.S. Army Corps of Engineers for the area where costs are incurred, shall be used to determine ownership and/or operating costs of Contractor and/or subcontractor owned equipment.

(iii) Standby allowance for owned equipment shall be 50 percent of the ownership cost as determined above, and standby time will not exceed 8 hours in any 24 hour period. No more than 40 hours of standby allowance will be paid during a 1 calendar-week period.

- Other direct costs - Bonds, mobilization, demobilization, permits, royalties, etc., shall be supported by invoices, quotes, rates, etc., to the satisfaction of the Contracting Officer.

- Production rates - Provide hours of performance required or projected for each labor classification and each piece of equipment.

- Subcontractor costs - Provide support data as required of the Contractor above.

Overhead, Profit, and Markup

- The Contractor shall provide any available data with which to base negotiations for overhead, profit, and markup factors. These percentages may vary according to the nature, extent, and complexity of the work involved, but in no case shall exceed the following unless the Contractor demonstrates entitlement to a higher percentage:

| | Overhead (%) | Profit (%) | Markup (%) |
|---|---|---|---|
| To Contractor on work performed by other than its own forces | | | 5 |
| To first tier subcontractor on work performed by its subcontractors | | | 5 |
| To Contractor and/or the sub-contractors for that portion of the work performed with their respective forces | 10 | 10 | |

- The overhead factor shall be applied to the direct costs allowed above. The profit factor shall be applied to the total of the direct costs and overhead costs. The markup factor shall be applied to the total of the direct costs, overhead costs, and profit. The Contractor shall not be allowed a markup on the markup received by the first tier subcontractor. No markup will be allowed below the first tier subcontractor.

(b) Request for time extension (if any) shall be submitted with the proposal and shall include sufficient information and dates to demonstrate whether and to what extent the change will delay the contract.

(c) After receipt of a proposal regarding a contract modification, the Contracting Officer shall act within 30 days; provided however, that when the necessity to proceed with a change does not allow time to check a proposal properly, or in the event of failure to reach an agreement on a proposal, the Government may order the Contractor to proceed on the basis of price to be determined at the earliest practicable date. If a mutually acceptable agreement cannot be reached, the Contracting Officer may determine the price unilaterally.

(d) All costs determined under this subsection shall be in accordance with the contract cost principles and procedures in Part 31 of the Federal Acquisition Regulation (FAR) and Part 1231 of the Department of Transportation FAR Supplement in effect on the date of this contract.

**109.08 Force Account Work.** Amend as follows:

(3) Additional Compensation. Delete the text of this paragraph and substitute the following:

Overhead and profit will be added as provided in Subsection 109.06A.

(b) Materials. Delete the text of this paragraph and substitute the following:

For materials delivered to the work and accepted, the Contractor will receive the actual cost of such materials including transportation charges paid (exclusive of machinery rentals as hereinafter set forth), to which overhead and profit will be added as provided in Subsection 109.06A.

(c) Equipment. Delete the text of this paragraph and substitute the following:

Equipment costs will be paid as provided in Subsection 109.06A.

(e) Subcontracting. Delete the text of this paragraph and substitute the following:

Administrative cost (markup) in connection with subcontract work will be paid as provided in Subsection 109.06A.

**109.10 Progress Payments.** The first sentence is amended to read:

Progress payments will be made monthly as the work proceeds in accordance with FAR Contract Clauses 52.232-5 and 52.232-27, except that no payment will be made for less than $1,000.

Add the following:

The Engineer will prepare a monthly estimate of work completed and amount due for the progress payment. The Contractor's monthly invoice or estimate of work completed and amount due shall be in accordance with the Engineer's estimate of work completed prior to its acceptance by the billing office, as indicated by the Contractor's signature on each estimate.

**109.12 Acceptance and Final Payment.** The first sentence is amended to read:

See FAR Contract Clauses 52.232-5 and 52.232-27.

## Section 311.--STOCKPILED AGGREGATES

Delete the text of this Section and substitute the following:

### Description

311.01 This work shall consist of furnishing and placing the specified aggregates in stockpiles at Contractor furnished and prepared sites at or near the point of production.

### Materials

311.02 **Aggregates.** Material used in the production of chip seal aggregate and slurry seal aggregate shall be obtained from sources selected by the Contractor in accordance with the requirements of Subsection 106.01. Stockpiled aggregates shall conform to Subsection 703.13.

Acceptance sampling and point of acceptance are specified in Subsection 106.06. The Government shall have unrestricted access to stockpile sites.

### Construction Requirements

311.03 **Stockpile Site Provided by the Contractor.** The contract does not provide stockpile site(s) for the use of the Contractor. Aggregates shall be stockpiled at site(s) selected by the Contractor and approved by the Engineer. Other methods of preparing the stockpile and preventing contamination of the stockpiled aggregate may be acceptable when approved by the Engineer.

311.04 **Preparation of Site.** Before placing aggregates upon the stockpile site, the site shall be cleared of vegetation, trees, stumps, brush, rocks, or other debris and the ground leveled to a smooth, firm, uniform surface. After the site has been graded and compacted, a layer of crushed aggregate shall be placed over the entire stockpile area and compacted. The depth of the aggregate placed shall be sufficient to stabilize the floor of the site to prevent contamination of the stockpiled aggregate with soil or other deleterious materials.

311.05 **Construction of Stockpiles.** Stockpiles shall be constructed upon the prepared sites approved by the Engineer. The piles when completed shall be neat and regular in shape and shall occupy the smallest feasible area as practical. The side slopes shall not be flatter than 1-1/2:1.

To avoid segregation of the various sizes in each stockpile, the stockpiles shall be built up in layers of not more than 4 feet in depth. Stockpile layers shall be constructed by trucks, clamshells, or other methods approved by the Engineer. Pushing aggregates into piles with a bulldozer will not be permitted. Each layer shall be completed over the entire area of the pile before depositing aggregates in the succeeding layer. The aggregate

shall not be dumped so that any part of it runs down and over the lower layers in the stockpile. The method of dropping from a bucket or spout in one location to form a cone shaped pile will not be permitted. Any method of placing aggregates in stockpiles which, in the opinion of the Engineer, breaks, degrades, or otherwise damages the aggregate will not be permitted. Plank runways will be required, when deemed necessary by the Engineer, for operating trucks on stockpiles to avoid tracking dirt or other foreign matter onto the stockpiled materials.

No equipment other than pneumatic-tired equipment shall be used in constructing the stockpiles of aggregates.

Stockpiles of aggregate shall be spaced far enough apart or separated by suitable walls or partitions to prevent the mixing of the aggregates. Aggregate shall not be deposited where traffic, vehicles, or equipment will either run over or through the piles or in any way cause foreign matter to become mixed with the aggregates.

Stockpiled aggregate, once tested and approved, shall be covered to provide protection from the weather and remain available for exclusive use in this contract.

**311.06 Removing Aggregates from Stockpiles.** Aggregate shall be removed from the stockpile and handled in a manner acceptable to the Engineer that will minimize segregation, degradation and contamination. When removing materials from the face of the stockpile, the equipment shall be operated in a manner to face-load from the floor to the top of the stockpile to obtain maximum uniformity of material. Excessive rehandling of aggregates resulting in segregation, degradation or contamination will not be permitted.

## Method of Measurement

**311.07** Aggregates to be placed in stockpile will be measured by the ton.

If, in the opinion of the engineer, the aggregates as measured for payment contain excessive moisture, all moisture in excess of 2 percent of the dry weight of the aggregate will be deducted from the quantity measured for payment.

## Basis of Payment

**311.08** The accepted quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each of the particular pay items listed below and shown in the bid schedule, which prices and payments will be full compensation for the work prescribed in this Section.

The quantity of aggregate to be placed in stockpile is more than sufficient to construct the treated areas. Loss of material due to the Contractor's method of operation or rejection of material by the Engineer due to contamination, segregation, or other reasons will not be cause for payment of increased quantity above that shown in the bid schedule.

All excess aggregates remaining in stockpiles after satisfying the needs of the contract shall become the property of the Contractor.

All costs associated with the acquisition of the site(s), the preparation of the site(s), construction of the stockpiles, disposal of excess aggregates, site restoration, and cleanup shall be included in the unit contract price for the various bid items being stockpiled.

Payment will be made under:

| | Pay Item | Pay Unit |
|---|---|---|
| 311(1) | Aggregate for chip seal in stockpile | Ton |
| 311(2) | Aggregate for slurry seal in stockpile | Ton |

## Section 407.--CHIP SEAL
## (ADDED SECTION)

### Description

407.01 This work consists of furnishing and transporting all materials, equipment, and labor for constructing the asphalt chip seal surface treatment areas. The treatment areas shall be constructed on the existing pavement in accordance with these specifications and in conformance with details and at the locations shown on the plans. There is one treatment area for chip sealing at each project site.

### Equipment

407.02 The equipment used by the Contractor shall include but not be limited to the following:

(a) Power Broom. A motorized power broom, center mount only, shall be used for removing loose material from the surface to be treated and for removing loose aggregate after work is completed.

(b) Asphalt Distributor. A pressure distributor shall be used for applying the asphalt material. It shall be designed and operated to distribute the asphalt material in a uniform spray at the specified rate without atomization. It shall be equipped with a bitumeter having a dial registering feet of travel per minute. The dial shall be visible to the operator in order to maintain the constant speed required for the application at the specified rate. The pump shall be equipped with a tachometer having a dial registering gallons (or liters) per minute passing through the nozzles. The dial shall be readily visible to the operator. The distributor shall be provided with a full circulatory system that includes the spray bar. The distributor shall be provided with heaters that can be used to bring the asphalt material to spray application temperature. Means shall be provided for accurately indicating the temperature of the asphalt material at all times. The thermometer well shall not be in contact with the heating tube. The normal width of application of the spray bar shall be 13 feet with provision for greater or lesser width when necessary. A hose and spray nozzle attachment shall be provided for applying asphalt material to patches and areas inaccessible to the spray bar. The spray bar height, nozzle angle, and pump pressure will be calibrated weekly or as required by the Engineer. The calibration shall be performed in accordance with the Asphalt Institute Manual Series No. 19, 2nd Edition. The allowable deviation shall be not more than 10 percent in the longitudinal and transverse directions. The longitudinal and transverse spread rates shall be checked using ASTM Test Method D 2995.

(c) Aggregate Spreader. The aggregate spreader shall be a self-propelled mechanical spreader capable of uniformly distributing aggregate at the prescribed rate. The aggregate spreader shall be checked weekly or as required by the Engineer. The calibration of the aggregate spreader shall be performed in accordance with the Asphalt Institute Manual Series No. 19, 2nd Edition. The allowable deviation in the amount of aggregate spread shall not be more than 10 percent (by weight) in the longitudinal or transverse directions.

(d) Rollers. A sufficient number of self-propelled pneumatic-tired rollers shall be used for rolling aggregates after spreading such that the entire lane width of the treatment area is covered in one pass of the rollers. Each pneumatic-tired roller shall have a total compacting width of not less than 60 inches and shall have a minimum ground contact pressure of 80 pounds per square inch.

(e) Hauling Equipment. Vehicles used for hauling aggregate shall have a cover of canvas or other suitable material of such size as to protect the aggregate from weather. Aggregates shall be covered during delivery to the project sites.

(f) Auxiliary Equipment. Air compressors, water flushing equipment, hand brooms, shovels, and other equipment shall be used as necessary to perform the work.

## Materials

**407.03 Asphalt.** Asphalt shall conform to the requirements of Subsection 702.03, Emulsified Asphalts and shall be obtained from a source selected by the Contractor that will assure compatibility with the aggregate selected.

Acceptance sampling and point of acceptance are specified in Subsection 106.06.

**407.04 Aggregates.** Aggregates shall meet the requirements of Subsection 703.13, Table 703-1.

Point of acceptance is specified in Subsection 106.06.

**407.05 Water.** All water shall be potable and compatible with the chip seal. Compatibility must be ensured by the Contractor.

**407.06 Mix Design.** The chip seal coat shall be designed in accordance with the Asphalt Institute design method found in their Manual Series No. 19, 2nd Edition. The Contractor shall have the design of the chip seal prepared by qualified personnel experienced in asphalt surface treatment design.

The surface treatment design shall be based on traffic of over 2,000 vehicles per day and assume a slightly pocked, porous oxidized surface.

Application rate for the emulsified asphalt shall be from 0.25 and 0.45 gallon per square yard. The final application rate shall be determined after the source of materials is known.

Spread rate for the aggregate, based on weight of dry aggregate, shall be from 20 to 40 pounds per square yard. The final application rate shall be determined after the source of materials is known.

The design of the surface treatment shall be submitted to the Engineer for approval 21 days prior to any work being accomplished. The design will include the following information:

(a) Aggregate gradation.
(b) Bulk specific gravity of aggregate.
(c) Loose unit weight of aggregate.
(d) Asphalt rate of application and type.
(e) Aggregate rate of application.

In addition to the above data, the Contractor shall submit with the design of the surface treatment a sample of the aggregate and the emulsion for use by the Engineer for verifying test results. The design may be verified by the Government.

After the design mix has been established, the mixture supplied to the project shall conform to the following tolerances:

| | |
|---|---|
| Passing U.S. No. 4 and larger sieves | ± 7% |
| Passing U.S. No. 8 to U.S. No. 100 sieve | ± 4% |
| Passing U.S. No. 200 sieve | ± 2% |
| Residual Asphalt (by extraction) | ± 0.4% |

## Construction Requirements

**407.07 Weather Limitations.** The chip seal surface treatment shall be placed only when the surface to be treated is dry, when the temperature of the pavement surface and the air temperature is 60 degrees F and rising, and when the weather is not foggy or rainy.

**407.08 Preparation of Surface, General.** All roadway surfaces to be treated shall be cleaned by the Contractor. The Contractor shall sweep the pavement with a motorized power broom to remove all loose material. All depressions not reached by the power broom will be cleaned by the Contractor using hand brooming. The Contractor shall insure that the outer edges of the pavement to be treated including the 1 foot of the shoulder width are thoroughly cleaned. Work will not continue until the surface is approved by the Engineer.

407.09 Temporary Centerline Markings. Prior to the placement of the chip seal surface treatment, temporary centerline marking meeting the requirements of Section 640 shall be installed by the Contractor.

407.10 Application of Emulsified Asphalt. Emulsified asphalt shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing. Application of emulsified asphalt shall be made only when the surface is dry as determined by the Engineer.

The rate of application for the emulsified asphalt shall be at the rate determined by the surface treatment design. See Subsection 407.06. The Engineer will make adjustments to the rate of application if necessary. Application of the emulsified asphalt shall be made uniformly at this rate with the pressure distributor, one full lane width at a time (including shoulder). Further adjustments in the rate of application will be made by the Engineer, if needed, during the course of the work. The emulsified asphalt shall be applied at a temperature between 125 and 185 degrees F. The final spray temperature will be specified by the Engineer.

Before beginning application, building paper shall be spread over the surface, from the beginning point back and from the endpoint forward, for a sufficient distance for the spray bar to be at full force when the surface to be treated is reached. The spray bar shall be shut off instantaneously at the endpoint to ensure a straight line and the full application of asphalt up to the endpoint. After the emulsified asphalt is applied, the building paper shall be removed and disposed of properly.

407.11 Application of Aggregates. Immediately after the emulsified asphalt has been spread evenly over the roadway surface, aggregates of the type specified shall be evenly applied to the roadway surface by self-propelled spreader equipment. The aggregate shall be distributed uniformly by a spreader within 1 minute of the emulsified asphalt application.

All aggregate shall be moistened prior to placement to provide aggregates that are uniformly damp at the time of placement on the roadway.

The aggregate shall be spread in one operation in such a manner that an 8 inch strip of emulsified asphalt is left exposed along the longitudinal center joint to form a lap for succeeding applications of asphalt. If necessary, thin or bare spots in the spread of aggregates shall be corrected by hand spreading or other methods subject to the approval of the Engineer.

The aggregate shall be spread at the rate determined by the surface treatment design. See Subsection 407.06. The Engineer will make adjustments to the rate of application if necessary.

The aggregate shall be rolled following spreading. A maximum time of 3 minutes will be allowed between the spreading of the aggregate and completion of the initial rolling of that aggregate. The rollers shall proceed in a longitudinal direction at a speed less than or equal to 5 miles per hour. The rollers shall make three complete coverages of the aggregate with the final pass being in the direction of traffic.

At the direction of the Engineer, prior to opening to traffic, the surface of the roadway shall be swept with a power broom at adequate pressure to remove loose aggregate.

The operation of vehicles hauling aggregate shall be so regulated that no damage as determined by the Engineer will result to the roadway or the freshly applied surface.

## Method of Measurement

407.12 Asphalt will be measured by the ton. The quantity to be measured will be the number of tons indicated in the bid schedule or authorized by the engineer.

Chip sealing will be measured by the each for the actual number of test sections completed and accepted.

## Basis of Payment

407.13 The accepted quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each of the particular pay items listed below and shown in the bid schedule.

The quantity of asphalt shown in the bid schedule is more than sufficient to construct the treated areas. Loss of material due to the Contractor's method of operations or rejection of material by the Engineer due to contamination or other reasons will not be cause for payment of increased quantity above that shown on the bid schedule. All excess asphalt remaining after satisfying the needs of the contract shall become the property of the Contractor.

Payment for Pay Item 407 (1) Asphalt for Chip Seal, will be made to the contractor upon presentation of proof of purchase (paid invoice) for the quantity shown in the bid schedule, or authorized by the Engineer.

The unit contract price per each for "Chip sealing" shall be full payment to complete the work as specified, including all costs for labor, tools, equipment, materials, and transportation. This includes but is not limited to the following:

(a) Water necessary for brooming the surface.
(b) Calibration of equipment.
(c) Furnishing and placing temporary raised pavement markers.
(d) Water necessary for wetting the aggregate.
(e) Placement of the materials on the roadway.
(f) Brooming after placement is complete.

The cost of preparing and furnishing the chip seal mix design shall be incidental to the work required under other items of the contract. No direct payment will be made for such work.

Payment will be made under:

| | Pay Item | Pay Unit |
|---|---|---|
| 407(1) | Asphalt for chip seal | Ton |
| 407(2) | Chip sealing per site | Each |

## Section 408.--SLURRY SEAL
## (ADDED SECTION)

### Description

408.01 This work consists of furnishing and transporting all materials, equipment, and labor for constructing conventional asphalt slurry seal treatment areas. The treatment areas shall be constructed on the existing pavement in accordance with these specifications and in conformance with details and at the locations shown on the plans. There is one treatment area for slurry sealing at each project site.

### Equipment

408.02 The equipment used by the Contractor shall include but not be limited to the following:

(a) Slurry Seal Mixer. The slurry seal mixing machine shall be a continuous flow mixing unit with calibrated controls capable of delivering accurately predetermined proportions of aggregate, water, and asphalt emulsion to the mixing chamber and of discharging the thoroughly mixed product on a continuous basis. Each machine shall be equipped with metering devices, easily readable, that will accurately measure all raw materials prior to entering the pugmill. Each machine shall have an automated system capable of automatically sequencing in all raw materials to insure constant slurry mixture. The mixing chamber shall be capable of thoroughly blending all ingredients together. No violent mixing will be permitted. The aggregate shall be pre-wetted in the pugmill immediately prior to mixing with the emulsion.

The mixer shall be equipped with an approved fines feeder having an accurate metering device or other approved means to introduce a predetermined quantity of mineral filler into the mixer at the time and location that the aggregate is introduced into the mixing machine. The fines feeder shall be used whenever mineral filler is a part of the aggregate blend.

The mixing machine shall be equipped with a water pressure system and a fog-type spray bar adequate for complete fogging of the surface immediately ahead of the spreading equipment. Rate of fog application shall be 0.03 to 0.06 gallon of water per square yard.

The mixer shall be capable of mixing all materials at preset proportions regardless of the engine speed without changing the mixing machine settings.

The machine shall be capable of a minimum speed of 60 feet per minute and shall not exceed 180 feet per minute while in operation. The mixing machine shall have sufficient storage capacity to properly mix and apply a minimum of 7 tons of slurry seal.

Approved means of measuring all materials used in each slurry seal batch shall be provided and made accessible to the Engineer by the Contractor. The slurry seal mixer shall be checked weekly or as required by the Engineer. The calibration of the slurry seal mixer shall be performed in accordance with the Asphalt Institute Manual Series No. 19, 2nd Edition. The Engineer may use the recorders and measuring facilities of the slurry seal unit to determine application rates, asphalt emulsion content, and mineral filler content of individual loads.

(b) Spreading Equipment. Attached to the mixing machine shall be a mechanical type single squeegee distributor equipped with flexible material in contact with the surface to prevent loss of slurry and adjustable to assure a uniform spread of varying grades and crowns. It shall be steerable and adjustable in width with a flexible strike-off.

The box shall not cause grooving of the slurry by any of its parts. It shall be kept clean, and build-up of material on the spreader will not be permitted. The type drag, burlap, or other textile will be approved by the Engineer and it shall be cleaned or changed as frequently as needed or as designated by the Engineer. The drag shall be wetted at the beginning of each application.

(c) Hauling Equipment. Vehicles used for hauling aggregate shall have a cover of canvas or other suitable material of such size as to protect the aggregate from weather. Aggregate shall be covered during delivery to the project sites.

(d) Auxiliary Equipment. Hand squeegees, shovels, and other equipment shall be used as necessary to perform the work. Cleaning equipment including but not limited to power brooms, air compressors, water flushing equipment, and hand brooms shall be adequate for surface preparation.

## Materials

**408.03 Asphalt.** Asphalt shall conform to the requirements of Subsection 702.03, Emulsified Asphalts and shall be obtained from a source selected by the Contractor that will assure compatibility with the aggregate selected.

Acceptance sampling and point of acceptance are specified in Subsection 106.06.

**408.04 Aggregates.** Aggregate shall meet the requirements of Subsection 703.13, Table 703-2.

Point of acceptance is specified in Subsection 106.06.

408.05 Mineral Filler. Mineral filler shall meet the requirements of Subsection 703.11. Mineral filler shall be obtained from a source selected by the Contractor in accordance with the requirements of Subsection 106.01.

Acceptance of mineral filler is specified in Subsection 106.06.

408.06 Water. All water shall be potable and compatible with the slurry seal. Compatibility must be ensured by the Contractor.

408.07 Mix Design. The slurry mixture shall be designed in accordance with requirements of ASTM D 3910, as applicable. The Contractor shall have a mix design prepared by one of the following laboratories:

Alpha Labs
P.O. Box 74
Alpha, OH 45301
(513) 298-6647
Contact: Ben Benedict

Asphalt Technologies, Inc.
9890 B Elder Creek Road
Sacramento, CA 95829
(916) 381-8033
Contact: Jim Stevens

Koch Materials
1194 Zinns Quarry Road
Reading, PA 17404
(717) 843-0975
Contact: Ron Kohlar

Scan Road, Inc.
P.O. Box 7677
Waco, TX 76714
(817) 772-7677
Contact: Tony Ng

Valley Slurry Seal Lab
P.O. Box 1620
W. Sacramento, CA 95691
(916) 373-1500
Contact: Jim Harriman

Sahuaro Labs
P.O. Box 6536
Phoenix, AZ 85005
(602) 252-3061
Contact: Mike Doyle

The mix design shall be based upon the requirement that the treated area will be opened to traffic within 2 hours after placement of the slurry seal mixture.

Application rate of slurry mixture is estimated to be from 15 to 25 pounds per square yard.

The mix design will be submitted to the Engineer for approval 5 days prior to any work being accomplished. The mix design will include the following information:

(a) Aggregate gradation.

(b) Mineral filler to be used if needed, percentage by weight of aggregate.

(c) Asphalt percentage and type.

(d) Sand equivalent of aggregate.

(e) Setting time (40 minute max).

(f) Water resistance test results; pass or fail.

(g) Results of Wet Track Abrasion Test (max. loss of 75 grams per sq ft).

In addition to the above data, the Contractor is to submit with the mix design a sample of the aggregate, the asphalt emulsion, and the mineral filler, for use by the Engineer to verify test results.

After the design mix has been established, the mixture supplied to the project shall conform thereto within the following tolerances:

| | |
|---|---|
| Passing U.S. No. 4 and larger sieves | ± 7% |
| Passing U.S. No. 8 to U.S. No. 100 sieve | ± 4% |
| Passing U.S. No. 200 sieve | ± 2% |
| Residual Asphalt (by extraction) | ± 0.4% |
| Accelerator (portland cement) | ± 0.2% |

The Engineer may adjust the asphalt emulsion percentage during construction if necessary.

## Construction Requirements

**408.08 Weather Limitations.** Slurry seal shall be applied only when the surface to be treated is dry or slightly damp, when the temperature of the road surface and the air temperature is 60 degrees F and rising, and when the weather is not foggy or rainy.

**408.09 Preparation of Surface, General.** All roadway surfaces to be treated shall be cleaned by the Contractor. The Contractor shall sweep the pavement with a motorized power broom to remove all loose material. All depressions not reached by the power broom will be cleaned by the Contractor using hand brooming. The Contractor shall insure that the outer edges of the pavement to be treated, including the 1 foot of the shoulder width, are thoroughly cleaned. Work will not continue until the surface is approved by the Engineer.

**408.10 Temporary Centerline Markings.** Following the placement and curing of the slurry seal surface treatment, temporary centerline marking meeting the requirements of Section 640 shall be installed by the Contractor.

408.11 Application of Slurry Seal. The surface shall be fogged with water immediately preceding the spreader. The slurry seal mixture shall be of the desired consistency as it leaves the mixer. The mixture furnished shall conform to the established design mix. The total mixing time shall not exceed 4 minutes. A sufficient amount of slurry seal mixture shall be carried in all parts of the spreader such that complete coverage of the surface is effected.

Treated areas will be allowed to cure until such time as the Engineer permits these treated areas to be opened to traffic.

The following will not be permitted:

(a) Lumping, balling, or unmixed materials.

(b) Segregation of the emulsion and aggregate fines from the coarse aggregate. If the coarse aggregate settles to the bottom of the slurry seal mix, the slurry seal mix shall be removed from the surface.

(c) Excessive breaking of the emulsion in the spreader box.

(d) Streaks or other unsightly appearances. The shoulder line should be uniform and straight.

(e) Excessive build-up of slurry seal mix on longitudinal or transverse joints.

## Method of Measurement

408.12 Asphalt will be measured by the ton. The quantity to be measured will be the number of tons shown in the bid schedule or authorized by the Engineer.

Slurry sealing will be measured by the each for the actual number of test sections completed and accepted.

## Basis of Payment

408.13 The accepted quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each of the particular pay items listed below and shown in the bid schedule.

The quantity of asphalt shown in the bid schedule is more than sufficient to construct the treated areas. Loss of material due to the Contractor's method of operations or rejection of material by the Engineer due to contamination or other reasons will not be cause for payment of increased quantity above that shown in the bid schedule.

All excess asphalt remaining after satisfying the needs of the contract shall become the property of the Contractor.

Payment for Pay Item 408(1), Asphalt for Slurry Seal, will be made to the contractor upon presentation of proof of purchase (paid invoice) for the quantity shown in the bid schedule, or authorized by the Engineer.

The unit contract price per each for "Slurry sealing" shall be full payment to complete the work as specified, including all costs for labor, tools, equipment, materials, and transportation. This includes but is not limited to the following:

(a) Water necessary for brooming the base surface.
(b) Calibration of equipment.
(c) Furnishing and placing temporary raised pavement markers.
(d) Placement of the materials on the roadway.
(e) Protecting the slurry seal throughout the curing period.

The cost of preparing and furnishing the slurry seal mix design shall be incidental to the work required under other items of the contract. No direct payment will be made for such work.

When mineral filler is required by the mix design, no direct payment will be made for furnishing and incorporating the mineral filler into the work. The cost of such work shall be incidental to the work required under other items of the contract.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 408(1) | Asphalt for slurry seal | Ton |
| 408(2) | Slurry sealing per site | Each |

## Section 409.--CRACK SEALING
## (ADDED SECTION)

### Description

409.01 This work consists of furnishing and transporting all materials, equipment, and labor for sealing cracks in the existing pavement in the treatment areas. Crack sealing shall be in accordance with these specifications and in conformance with details and at the locations shown on the plans. There is one treatment area for crack sealing at each project site.

### Equipment

409.02 The equipment used by the Contractor shall include but not be limited to the following:

(a) Hot-Compressed Air-Lance (HCA). The hot-compressed air-lance shall provide clean, oil-free compressed air at a volume of 100 cubic feet per minute at a pressure of 120 pounds per square inch and at a temperature of 2,000 degrees F.

(b) Application Wand and Sealant Heating Equipment. The crack sealant applicator wand shall be attached to a heated hose, attached to a heated sealant chamber. Temperature controls shall be capable of maintaining the temperature of the sealant within manufacturer's tolerances.

(c) Router. A hand controlled mechanical router specifically designed for routing cracks in pavements. The router shall have the ability to rout random cracks to the cross section specified at a minimum rate of 1,000 linear feet per hour.

(d) Squeegee. A hand held squeegee shall be used to ensure that the crack is filled flush to the existing surface. The squeegee shall be of the size and shape to ensure that a three inch wide band is centered on the finished sealed crack.

### Materials

409.03 The crack sealant shall be a polymer modified rubber asphalt and shall conform to the requirements of ASTM Designation D 3405 when tested in accordance with ASTM Designation D 3407. Crack sealant shall be obtained from a source selected by the Contractor in accordance with the requirements of Subsection 106.01. Crack sealant material shall be furnished from one production lot.

Acceptance of crack sealant is specified in Subsection 106.06.

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## Construction Requirements

409.04 **Preparation of Surface, General.** The pavement area to be treated shall be clean and dry with no standing or flowing water on the surface.

409.05 **Cracks to be Treated.** All cracks greater than 12 inches in length, and greater than 1/8 inch width shall be treated.

409.06 **Preparation of Cracks.** Cracks shall be routed to 1 1/2 inches wide and 3/8 inch deep. Sides of the routed cracks shall be vertical. The bits used to rout the cracks must be kept sharp and replaced when dull. All cracks shall be thoroughly cleaned of all foreign material.

409.07 **Cleaning the Crack.** All cracks shall be blown clean and dry using the HCA lance. Care shall be exercised to keep the HCA lance moving at a pace that will avoid burning the surrounding pavement.

409.08 **Sealing the Crack.** For each crack, the crack sealant shall be placed and finished within 5 minutes after heating with the HCA lance. Each crack shall be filled flush to the existing surface so that the finished sealed crack is approximately three inches wide and centered on the existing crack.

409.09 **Acceptance of Crack Sealing.** Following the application of the crack sealant and prior to the Government opening the roadway to traffic, the job will be visually inspected by the Engineer for areas exhibiting adhesion failure, damage to the sealant from construction equipment or personnel, missed cracks, foreign objects in the sealant, or other problems which will accelerate failure or indicate the job is not acceptable. Portions of the job identified by the Engineer that do not meet these criteria will be prepared and resealed until satisfactory to the Engineer.

## Method of Measurement

409.10 Crack sealant will be measured in pounds determined by the count of containers and partial containers actually used and the weight of each.

Crack sealing will be measured by the each for the actual number of test sections completed and accepted.

## Basis of Payment

409.11 The accepted quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each of the particular pay items listed below and shown in the bid schedule.

The unit contract price per pound for "Crack sealant for sealing" shall be full payment for all costs associated with furnishing the sealant to the project site.

The quantity of crack sealant shown in the bid schedule is more than sufficient to construct the treatment areas. Upon completion of all work it is expected that all excess, unused crack sealant material will be returned to the supplier. Payment will be made only for that quantity of material actually incorporated in the work.

The unit contract price per each for "Crack sealing per site" shall be full payment to complete the work as specified, including all costs for labor, tools, equipment, materials, and transportation. This includes but is not limited to the following:

(a) Brooming the base surface.
(b) Routing.
(c) Cleaning and drying the cracks.
(d) Placement of materials.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 409(1) | Crack sealant for sealing | Pound |
| 409(2) | Crack sealing per site | Each |

## Section 601.--MOBILIZATION

Delete the text of this Section and substitute the following:

### Description

601.01 Mobilization shall consist of preparatory work and operations, including but not limited to those necessary to the movement of personnel, equipment, supplies, and incidentals to the project sites, and for all other work and operations that must be performed or costs incurred prior to beginning work on the various items on the project sites.

The cost of performance and payment bond premiums shall be included in the bid amount for this item.

### Basis of Payment

601.02 Mobilization will be paid for at the contract lump sum price bid for the pay item listed below and shown in the bid schedule, which price and payment will be full compensation for the work prescribed in this Section. Partial payments will be made as the work progresses in accordance with the following schedule:

(a) When 5 percent of the original contract amount is earned from other bid items, 50 percent of the amount bid for mobilization will be paid.

(b) When 10 percent of the original contract amount is earned from other bid items, 100 percent of the amount bid for mobilization or 10 percent of the original contract amount, whichever is less, will be paid.

(c) Upon acceptance of all work on the project, payment of any amount bid for Mobilization in excess of 10 percent of the original contract amount, will be paid.

(d) At the written request of the Contractor and supported by evidence of full payment to the surety company, payment for performance and payment bond premiums will be as provided under FAR Contract Clause 52.232-5.

When payments as provided for in (d) above have been made, this amount shall be deducted from the amounts computed due in accordance with (a) and (b) above.

The total sum of all payments shall not exceed the original contract amount bid for mobilization, regardless of the fact that the Contractor may have, for any reason, shut down the work on the project or moved equipment away from the project and then back again.

When requested in writing by the Contractor, other partial payment schedules for mobilization will be used provided such schedules submitted do not exceed the payment schedule outlined above.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 601(1) | Mobilization | Lump sum |

## Section 635.--TEMPORARY TRAFFIC CONTROL

Delete the text of this Section and substitute the following:

### Description

635.01 All traffic control devices and services for the control of traffic at the various construction project sites will be provided by the Government (respective Provincial/State Highway Department). All other traffic control devices outside the project sites shall be furnished by the Contractor.

The existing road during the construction of the treatment areas will be kept open to all traffic. The Contractor shall conduct the work in a manner that provides for the safety and convenience of the public and workers, and protects the residents and property along the highway.

### Materials

635.02 Materials for traffic control devices will meet the requirements of the MUTCD.

### Construction Requirements

635.03 General. Necessary traffic control devices will be properly placed and in operation before construction is allowed to start.

If the Engineer determines that provisions for safe traffic control are not being provided or maintained, the work will be suspended.

635.04 Limitations on Construction Operations. The Contractor shall:

(a) Schedule movement of equipment onto the project sites only after traffic control devices are in place.

(b) Schedule operations to reduce traffic delays. The Engineer may suspend the work, either in whole or in part, when an excessive traffic delay occurs during a construction operation.

(c) Schedule construction operations to prevent interference with public travel on the roadway on any Federal, State, or Provincial legal holiday or holiday weekend. In addition, if a holiday falls on a Saturday, no construction operations interfering with public travel will be permitted on the roadway on the preceding Friday. If the holiday falls on a Sunday, the same shall apply to the following Monday.

(d) Perform construction operations only during the hours of daylight. Work during hours of darkness is prohibited unless authorized by the Engineer.

(e) Perform surfacing operations part-width at a time to facilitate public traffic. Accommodate public traffic under alternate one-way control on the width not under construction. The Government will furnish flaggers, pilot car and drivers, or both, to direct traffic through sections of road under one-way control.

(f) Provide a minimum lane width of 10 feet to maintain traffic flow.

(g) Coordinate with the Engineer on a location for a staging area. All staging area locations require the approval of the Engineer. Locate all staging area boundaries at least 30 feet from the edge of pavement. Access to and egress from the staging area requires the approval of the Engineer.

(h) Store material at the approved staging area or at alternate locations approved by the Engineer.

(i) Operate equipment in the direction of traffic, where practical.

(j) Park equipment either in the staging areas or at least 30 feet from the edge of travel lanes open to the public during nonwork hours.

(k) Provide parking areas for employee vehicles in approved areas.

Subsection 108.04 or other applicable Sections of work may address other limitations on construction operations.

No additional time will be allowed on this project for such nonwork periods as stated above as their effect was considered when establishing the completion date for this project.

**635.05 Opening Roadway to Traffic.** The roadway will be open to public traffic as follows:

The Government will open the roadway that has been sealed for cracks in accordance with manufacturer's recommendations.

The Government will keep traffic off the newly placed chip seal surface for at least 2 hours after rolling is complete.

The Government will keep traffic off the newly placed slurry seal in accordance with the guidelines of Section 7.6 of ASTM Designation D 3910.

**Measurement and Payment**

**635.06** No measurement or payment for the work described in this Section will be made. The cost of such work shall be incidental to the work required under other items of the contract.

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## Section 640.--TEMPORARY RAISED ROADWAY MARKERS (ADDED SECTION)

### Description

640.01 The Contractor shall furnish and install temporary raised roadway markers prior to the placement of the chip seal and after curing and prior to opening to traffic of slurry seal surface treatments.

Replacement of permanent traffic control pavement markings will be done by the respective Provincial/State Highway Department.

### Materials

640.02 Temporary raised roadway markers shall conform to the following:

The body of flexible-retroreflective roadway markers shall consist of a base and vertical wall made of polyurethane, polyester elastomer, or other acceptable material. The markers shall conform to the following dimensions:

| | |
|---|---|
| Base: | Length 3.5 inches to 4 inches<br>Width 1.125 |
| Vertical Wall: | Length 3.5 to 4 inches<br>Height 2 inches |

The reflective element on the upper portion of the vertical wall shall consist of a full length, 0.250 inch minimum width strip of retroreflective material. The retroreflective material shall display either white or yellow as required.

The reflective tape shall be made from metalized polycarbonate microprism retroreflective material with acrylic backing or equal.

Flexible-retroreflective roadway markers shall be of the following type:

AA - Two amber reflective surfaces with yellow body
A - One amber reflective surface with yellow body
C - One silver reflective surface with white body

Color used shall be in accordance with the MUTCD.

The base shall have a factory applied butyl rubber adhesive pad with an easily removed protective covering. The adhesive pad shall be approximately 1/8 inch in thickness, a minimum width of 3/4 inch, and run the full length of the marker tab.

The retroreflective element shall be protected with an easily removable cover of heat resistant transparent material capable of withstanding and protecting the reflective material from the application of 200 degree asphalt. Stapling or clipping devices used to retain the protective covering shall not protrude through the reflective material.

Flexible-retroreflective roadway marker tabs may be one of the following:

- Chip Seal Marker: Manufactured by M. V. Plastic, Inc., 533 W. Collins Avenue, Orange, California 92667, Telephone (714) 532-1522.
- Chip Seal Marker: Manufactured by Renco, Inc., Highway Control Products, P.O. Box 730, Pflugerville, Texas 78660, Telephone (512) 251-2422.
- Temporary Raised Pavement Markers: Manufactured by Davidson Plastics Company, 18726 E. Valley Highway, Kent, Washington 98032, Telephone (206) 251-8140.

Other temporary roadway markers of equal quality may be approved by the Engineer.

## Construction Requirements

640.03 The temporary centerline pavement markings shall be spaced at 40 foot gaps on the centerline for seal coat and chip seals. The placement criteria applies to white pavement lane markings for traffic moving in the same direction as well as yellow centerline for two-lane, two-way roadways.

The markers shall be installed on a dry, clean surface. The covers of the markers shall be removed by the Contractor prior to termination of traffic control.

## Measurement and Payment

640.04 No measurement or payment for work described in this Section will be made. All costs for labor, equipment, tools, and materials necessary to furnish and install the temporary raised roadway markers shall be incidental to the work required under the surface treatments.

Section 702.--BITUMINOUS MATERIALS

702.03 Emulsified Asphalts. Delete the text of this subsection and substitute the following:

(a) Emulsified asphalts for chip sealing shall conform to the following:

Emulsified Asphalt, Grade CRS-2 complying with AASHTO M 208, Table 1. The base asphalt to be emulsified shall be an AC 5 meeting the requirements of AASHTO M 226, Table 2.

(b) Emulsified Asphalt for slurry seal shall conform to the following:

Emulsified Asphalt, Grade CSS-1h complying with AASHTO M 208, Table 1 or Grade SS-1h complying with AASHTO M 140, Table 1. The cement mixing test is waived.

c) Material for crack sealant shall conform to ASTM D 3405.

703.13 Aggregate for Seal Coats, Cover Coats, and Surface Treatments. Delete the text under this subsection and substitute the following:

Aggregates shall meet the following requirements for grading and quality:

(a) Aggregates for Chip Seal. Aggregate shall be hard, durable particles or fragments of crushed stone or crushed gravel. Aggregates shall conform to the requirements of Table 703-1.

Table 703-1
Grading Requirements for Chip Seal Aggregate
(Percentage by Weight Passing U.S. Standard Sieves,
AASHTO T 27 and T 11)

| Sieve Designation | Percent Passing |
|---|---|
| 1/2" | 100 |
| 3/8" | 40 - 70 |
| No. 4 | 0 - 15 |
| No. 8 | 0 - 5 |
| No. 200 | 0 - 1.0 |

Not less than 75 percent by weight of the aggregate shall be particles having at least one fractured face. The fracture requirement shall apply to material retained on each sieve size No. 10 and above if that sieve retains more than 5 percent of the total sample.

The aggregate shall have a maximum flakiness index of 15 as determined by CFLHD DFT 508.

The aggregate shall have a minimum polish value of 32 as determined by AASHTO T 279.

The aggregate shall pass the static stripping test as determined by AASHTO T 182.

The aggregate shall show a durability factor not less than 35 (coarse and fine aggregate) as determined by AASHTO T 210.

Coarse aggregate shall have a percent of wear of not more than 30 at 500 revolutions as determined by AASHTO T 96.

The finished product shall be clean, uniform in quality, and free from wood, bark, roots, and other deleterious materials.

(b) Aggregates for Slurry Seal. Aggregate shall consist of manufactured sand or crusher fines, or other approved mineral aggregate or combination thereof. Aggregates shall conform to the requirements in Table 703-2 below for grading.

Table 703-2
Grading Requirements for Slurry Seal Aggregate
(Percentage by Weight Passing U.S. Standard Sieves,
AASHTO T 27 and T 11)

| Sieve Designation | Percent Passing |
|---|---|
| 5/16" | 100 |
| No. 4 | 70 - 90 |
| No. 8 | 45 - 70 |
| No. 16 | 28 - 50 |
| No. 30 | 19 - 34 |
| No. 50 | 12 - 25 |
| No. 100 | 7 - 18 |
| No. 200 | 5 - 15 |

Smooth, textured sand of less than 1.25 percent water absorption as determined by AASHTO T 84 shall not exceed 50 percent of the total combined aggregate.

The aggregate shall have a minimum sand equivalent of 55 as determined by AASHTO T 176, Alternate Method No. 2.

The finished product shall be clean, uniform in quality, and free from wood, bark, roots, and other deleterious materials.

The aggregate shall show a durability factor not less than 35 as determined by AASHTO T 210.

Material used in the production of the aggregate shall have a percent of wear of not more than 25 at 500 revolutions as determined by AASHTO T 96.